

- [54] **SIDEBANK EXCAVATOR WITH GRADE AND SLOPE CONTROL**
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- [51] Int. Cl.² E02F 9/20
- [58] Field of Search 37/110, 108 R, 108 A, 37/DIG. 20; 172/4.5; 180/41

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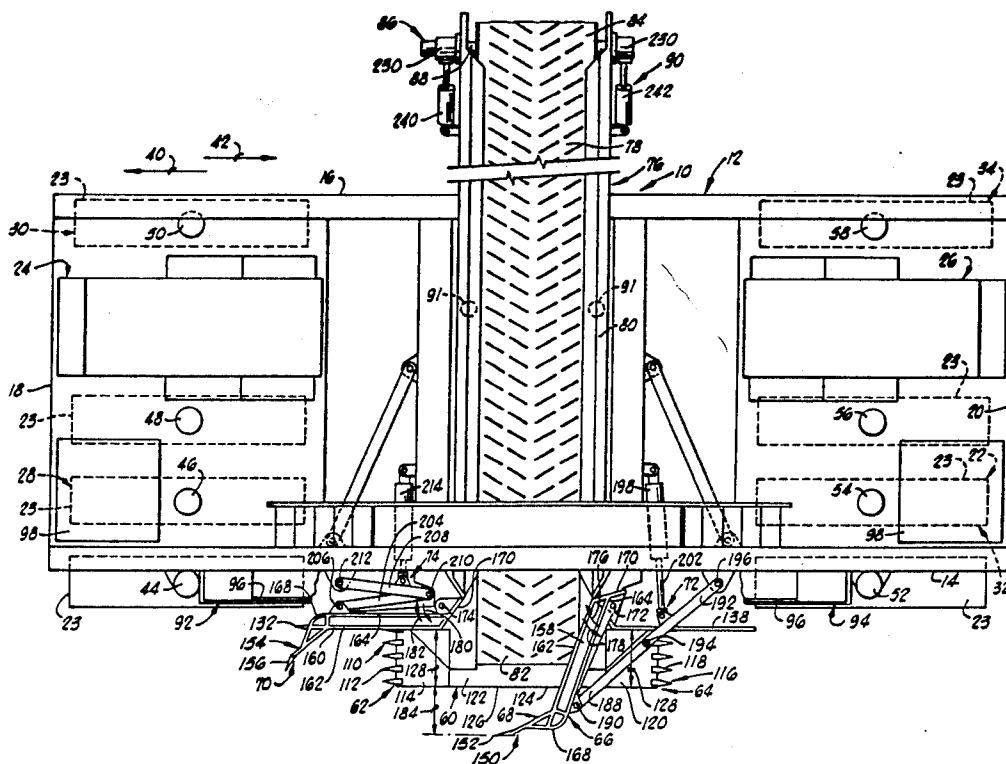
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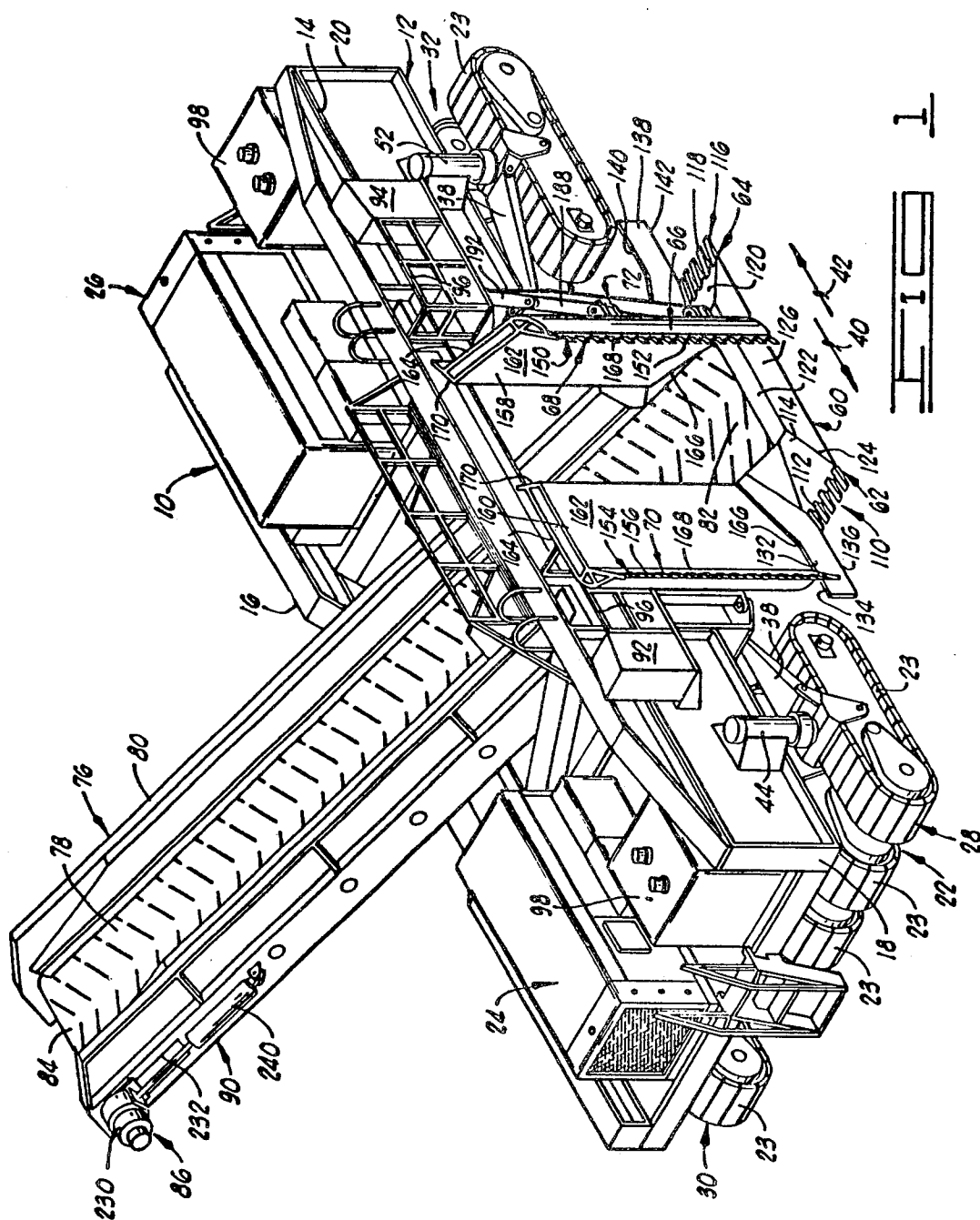
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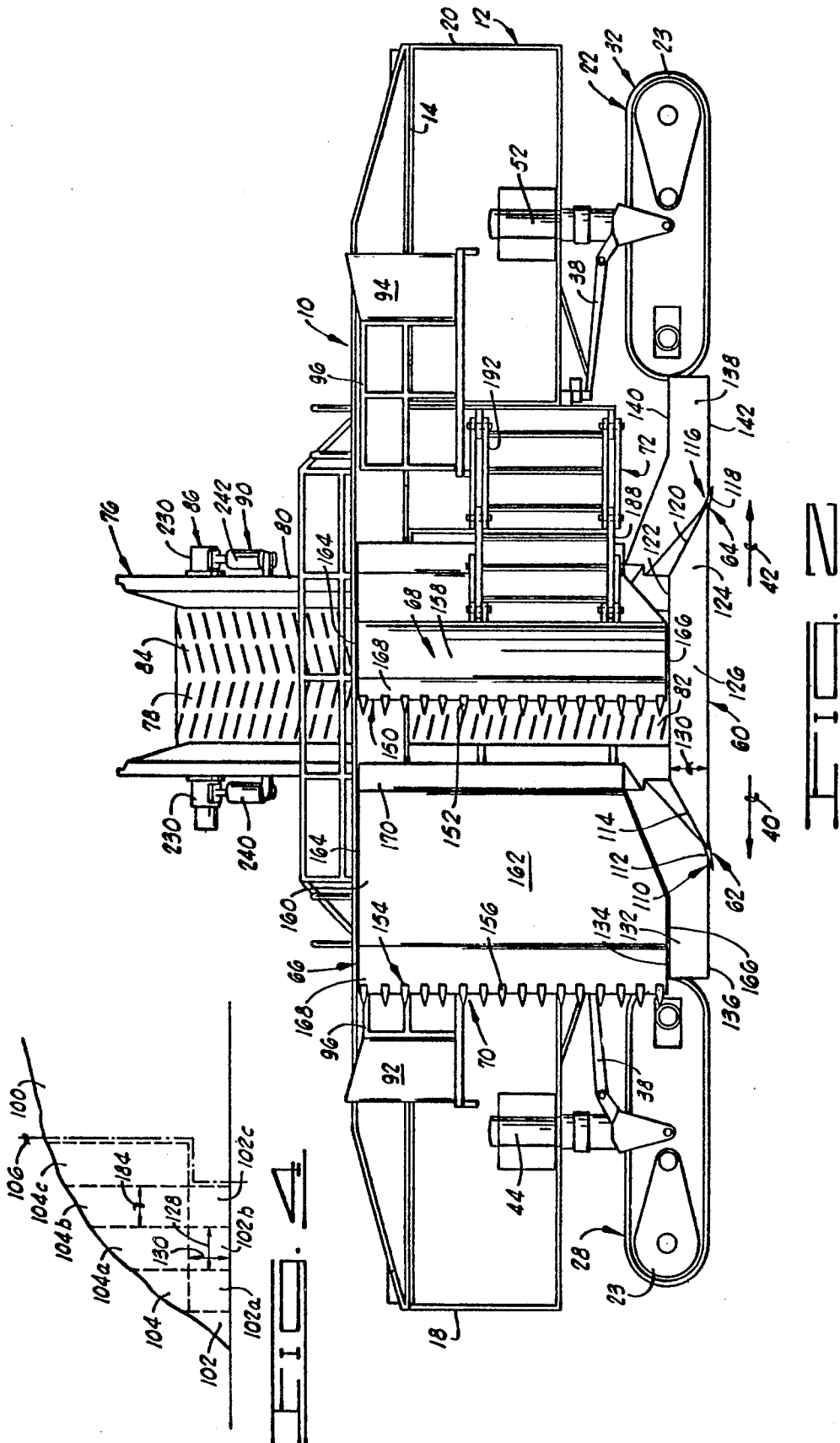
[57] ABSTRACT

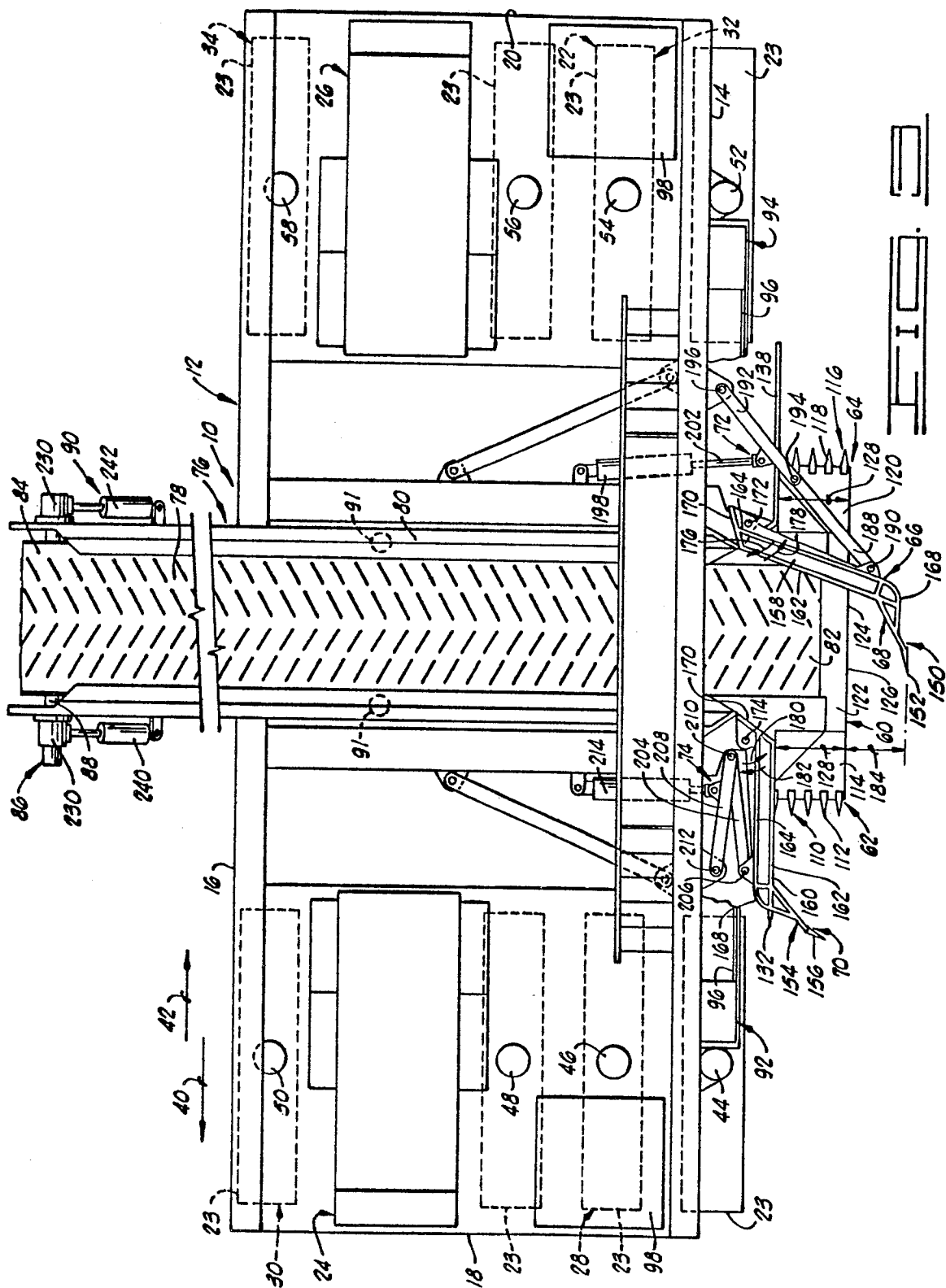
An improved sidebank excavator for excavatingly removing earth from a hill or a bank-like area, having a horizontal earth removal assembly, a vertical earth removal assembly and a plurality of track members, each track member connected to the excavator support frame via a track support member and a hydraulic cylinder such that the excavator support frame is vertically positionable in an upwardly and a downwardly direction. The hydraulic cylinders are hydraulically interconnected and controlled via a grade and slope control in such a manner that the support frame is vertically positionable about three predetermined control positions, for optimum positionability of the excavator.

3 Claims, 6 Drawing Figures









SIDEBANK EXCAVATOR WITH GRADE AND SLOPE CONTROL

REFERENCE TO RELATED APPLICATIONS

This application is a division of the applicants' co-pending application entitled "Side Bank Excavator", U.S. Ser. No. 142,725, filed May 12, 1971 now U.S. Pat. No. 3,778,912, assigned to the assignee of the present invention.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to improvements in earth working apparatus and, more particularly, but not by way of limitation, to an improved sidebank excavator having a grade and slope control vertically positioning the excavator about three predetermined control positions.

2. Description of the Prior Art

In the past, there have been various types of earth working apparatus designed and constructed to dig, excavate, scrape, cut and otherwise engage portions of earth to move, remove, and reshape the engaged earth for various purposes such as, for example, highway construction and land fills. In those instances where the earth must be excavatingly removed from a hillside or a bank or the like, some apparatus has been constructed to excavatingly engage a portion of the bank-like area generally along a vertical plane, while moving the earth working apparatus in a generally forward direction. When earth was excavated in this manner from a bank-like area, the earth working apparatus was generally positioned in a predetermined initial position, generally near the bank, subsequent to the earth working apparatus being moved in a forward direction, prior to each excavating pass along the bank.

The earth working apparatus of the past, constructed to excavatingly engage a portion of earth generally along a vertical plane, has generally been constructed in a relatively small size, thereby reducing the cubic yards of earth removed during each pass thereof or has been constructed such that the apparatus must be repositioned at the initial starting position subsequent to making each additional pass along the bank-like area, thereby expending a considerable amount of machine time and man power in maneuvering the earth working apparatus to a working position thereof. The problem of repositioning the earth working apparatus prior to making subsequent excavating passes along the bank-like area becomes extremely important when utilizing such earth working apparatus in those situations wherein there is a considerable distance between the starting position and terminating position, thereby considerably increasing the machine time and manpower lost in the repositioning of the earth working apparatus.

It should also be noted that the repositioning problem becomes even more complex and costly, in those instances where the earth working apparatus must be constructed large enough to fulfill a particular capacity requirement to economically complete a particular earth working project. It will be apparent to those skilled in the art that, as the excavating capacity of the earth moving apparatus is increased, the physical size of the earth working apparatus will also be increased, thus adding an additional complex and costly factor to be considered when utilizing earth working apparatus

which must be repositioned subsequent to each excavating pass along the bank-like area.

SUMMARY OF THE INVENTION

One object of the invention is to provide an excavator to excavatingly engage a portion of earth generally along a vertical plane wherein the earth excavating apparatus is positionable to excavatingly engage the earth in a forward and a rearward moving direction of the excavator.

Another object of the invention is to provide an excavator to excavatingly remove earth from a bank or the like in a more efficient manner and more economical manner.

Another object of the invention is to provide an excavator which is positionable to predetermined grade and slope positions, in a more efficient manner.

Yet another object of the invention is to provide an excavator which is positionable to predetermined grade and slope positions about three predetermined control positions.

Another object of the invention is to provide a more efficient control apparatus for automatically positioning an earth working apparatus relative to a horizontal plane.

A still further object of the invention is to provide an excavator which is economical in construction and operation.

Other objects and advantages of the invention will be evident from the following detailed description when read in conjunction with the accompanying drawings which illustrate a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an excavator constructed in accordance with the present invention.

FIG. 2 is a side elevational view of the excavator of FIG. 1.

FIG. 3 is a top plan view of the excavator of FIG. 1.

FIG. 4 is a diagrammatic view of a bank-like area of earth, taken substantially along a vertical plane there-through.

FIG. 5 is a fragmentary, partially diagrammatic view of a portion of the excavator of FIG. 1, showing the connection of the positioning apparatus to the vertical earth removal assembly.

FIG. 6 is a partial diagrammatic, partial schematic view showing the connection of the grade and slope control apparatus of the excavator of FIG. 1, utilized to automatically position the excavator in predetermined grade and slope positions.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings in general, and to FIGS. 1, 2 and 3 in particular, shown therein and designated by the general reference numeral 10 is an excavator which includes a support frame 12, having a cutting side 14, an earth removal side 16, a forward end 18, and a rearward end 20. It should be initially noted that the terms "forward" and "rearward", as used above to designate the opposite ends of the excavator 10, and as will be used below to designate various assemblies and components of the excavator 10 and directions of movement of the excavator 10, are utilized herein for the purpose of clarity of description, and such terms are relative in

that either end of the excavator 10 could be, for example, designated as the forward end or the rearward end thereof, as will be made more apparent below.

The excavator 10 and, more particularly, the support frame 12 thereof is drivingly supported by a track assembly 22 which includes a plurality of endless track members 23, some of the endless track members 23 being drivingly connected to a forward power drive 24, which is supported on the support frame 12, generally near the forward end 18 thereof, and some of the endless track members 23 being drivingly connected to a rearward power drive 26, which is supported on the support frame 12, generally near the rearward end 20 thereof. More particularly, the track assembly 22 includes a first forward track assembly 28, a second forward track assembly 30, a first rearward track assembly 32 and a second rearward track assembly 34. Each track assembly 28, 30, 32 and 34 includes a predetermined number of endless track members 23, each endless track member 23 being pivotally connected to the support frame 12 via a track support member 38, for reasons which will be made more apparent below.

The first forward track assembly 28 includes three endless track members 36, and is connected to a portion of the support frame 12 generally near the forward end 18 and near the cutting side 14 thereof. The second forward track assembly 30, more particularly, includes a single endless track member 36, and is connected to a portion of the support frame 12 generally near the forward end 18 and near the earth removal side 16 thereof. The first rearward track assembly 32 includes three endless track members, and is connected to a portion of the support frame 12 generally near the rearward end 20 and near the cutting side 14 thereof. The second rearward track assembly 34, more particularly, includes a single endless track member 23, and is connected to a portion of the support frame 12 generally near the rearward end 20 and near the earth removal side 16 thereof.

Each endless track member 23 of the first forward track assembly 28 and second forward track assembly 30 is, more particularly, drivingly connected to the forward power drive 24, such that the forward power drive 24 drives each endless track member 23 connected thereto, to move the excavator 10 in a generally forward direction 40 and in a generally rearward direction 42. Each endless track member 23 of the first rearward track assembly 32 and the second rearward track assembly 34 is drivingly connected to the rearward power drive 26, such that the rearward power drive 26 drives the endless track members 23 connected thereto, to move the excavator 10 in a generally forward direction 40 and in a generally rearward direction 42.

The forward power drive 24 and the rearward power drive 26 thus provide the driving impetus to move the excavator 10 in a forward direction 40 and in a rearward direction 42 during the operation of the excavator 10, as will be described in greater detail below. The forward power drive 24 and the rearward power drive 26 may be of a conventional design such as, for example, a diesel powered engine, and the construction and operation of such a power unit, and the various interconnecting components and operation thereof to drivingly connect the power unit to the endless track members are well known in the art, and a detailed description thereof is not required herein.

The excavator 10 includes a grade and slope control apparatus to automatically position the support frame 12 in predetermined grade and slope positions. The grade and slope control apparatus of the excavator 10, which will be described in greater detail below, includes a plurality of double-acting hydraulic cylinders, each hydraulic cylinder having a portion thereof connected to a portion of one of the endless track members 23 and another portion thereof connected to the support frame 12. More particularly, the grade and slope control apparatus includes three first forward hydraulic cylinders 44, 46 and 48, a second forward hydraulic cylinder 50, three first rearward hydraulic cylinders 52, 54 and 56, and a second rearward hydraulic cylinder 58, as shown more clearly in FIG. 3. Each hydraulic cylinder 44, 46, 48, 50, 52, 54, 56 and 58, includes a reciprocating piston (not shown) mounted in a cylinder (not shown), and has an actuated raising position wherein the support frame 12 is raised relative to the track assemblies 28, 30, 32 and 34, and an actuated lowering position wherein the support frame 12 is lowered relative to the track assemblies 28, 30, 32 and 34, in a manner to be described in greater detail below.

The excavator 10, as shown in FIGS. 1, 2 and 3, includes a horizontal earth removal assembly 60, which is generally connected to a central portion of the cutting side 14 of the support frame 12. The horizontal earth removal assembly 60 includes a forward portion 62 which is constructed and disposed to excavatingly engage a portion of earth generally along a horizontal plane, in a forward moving direction of the support frame 12, and a rearward portion 64 which is constructed and disposed to excavatingly engage a portion of earth generally along a horizontal plane, in a rearward moving direction 42 of the support frame 12.

The excavator 10 also includes a vertical earth removal assembly 66 which is generally connected to a central portion of the cutting side 14 of the support frame 12. The vertical earth removal assembly 66 includes a forward portion 68 which is constructed and disposed to excavatingly engage a portion of earth generally along a vertical plane, in a forward moving direction 40 of the support frame 12, and a rearward portion 70 which is constructed and disposed to excavatingly engage a portion of earth along a generally vertical plane, in a rearward moving direction 42 of the support frame 12. The forward portion 68 and the rearward portion 70 of the vertical earth removal assembly 66 are each movably connected to the support frame 12 such that the forward portion 68 and the rearward portion 70 can each be positioned to an earth engaging position, as shown in FIGS. 1, 2 and 3 with respect to the forward portion 68, and to a storage position, shown in FIGS. 1, 2 and 3 with respect to the rearward portion 70, for reasons and in a manner to be described in greater detail below.

The vertical earth removal assembly 66, as described generally above, also includes a forward positioning assembly 72, which has a portion thereof connected to the forward portion 68 and another portion thereof connected to the support frame 12. The forward positioning assembly 72 is constructed and connected to the forward portion 68 of the vertical earth removal assembly 66 to move the forward portion 68 to an earth engaging position, as shown in FIGS. 1, 2 and 3, wherein the forward portion 68 excavatingly engages a predetermined portion of earth, and to move the for-

ward portion 68 to a storage position, similar to that shown in FIGS. 1, 2 and 3 with respect to the rearward portion 70.

The vertical earth removal assembly 66 also includes a rearward positioning assembly 74, having a portion thereof connected to the rearward portion 70 and another portion thereof connected to the support frame 12, to position the rearward portion 70 in an earth engaging position, similar to that shown in FIGS. 1, 2 and 3 with respect to the forward portion 68, wherein the rearward portion 70 excavatingly engages a predetermined portion of earth, and to move the rearward portion 70 to a storage position as shown in FIGS. 1, 2 and 3.

As shown in FIGS. 1, 2 and 3, the excavator 10 includes a conveyor assembly 76 having a belt-like conveyor 78 supported via a conveyor support frame 80, which extends angularly generally over the support frame 12, generally between the cutting side 14 and the earth removal side 16 thereof. The conveyor 78 has a receiving end 82 and a disposing end 84, and is disposed and constructed to move the excavated earth deposited thereon generally toward the disposing end portion 84 thereof, and to deposit the excavated earth so moved by the conveyor 78 in a predetermined area, that is an area generally determined by the disposition of the disposing end 84 of the conveyor 78.

The receiving end portion 82 of the conveyor 78 is disposed generally between the forward portion 62 and the rearward portion 64 of the horizontal earth removal assembly 60, and generally between the forward portion 68 and the rearward portion 70 of the vertical earth removal assembly 66. The receiving end portion 82 of the conveyor 78 is thus disposed to receive the earth excavated by the horizontal earth removal assembly 60 and the vertical earth removal assembly 66, in a forward moving direction 40 and a rearward moving direction 42 of the support frame 12, during the operation of the excavator 10, in a manner to be described in greater detail below.

The conveyor assembly 76 includes a conveyor drive 86 which is drivingly connected to the conveyor 78, generally near the disposing end 84 thereof, to drive the conveyor 78 in a direction generally from the receiving end 82 toward the disposing end 84 thereof, in an actuated position of the conveyor drive 86.

It should be particularly noted that the belt-like conveyor 78 is, more particularly, of the endless belt type and the conveyor drive 86 is thus drivingly connected to the conveyor 78 via a conveyor drive shaft 88, as shown more clearly in FIG. 3. The conveyor drive shaft 88 drivingly engages a portion of the conveyor 78, generally near the disposing end 84 thereof, and the conveyor drive 86 is, more particularly, drivingly connected to the conveyor drive shaft 88. It will be apparent from the foregoing that the above designations referring to the "receiving end" 82 and the "disposing end" 84 of the conveyor 78, refer more particularly to relative positions, rather than specific portions of the conveyor 78, the designations being used merely for identification and for the purpose of clarity of description.

The conveyor assembly 76 also includes a conveyor control apparatus 90 having a portion thereof connected to the conveyor 78 to automatically adjust the tension of the conveyor 78 to predetermined tension positions, and another portion thereof to sensibly en-

gage a portion of the conveyor 78, and to automatically align the conveyor 78 to a predetermined alignment position, in response to a sensed position of the conveyor 78.

In a preferred form, the excavator 10 includes a pair of hydraulic cylinders 91 (shown in dashed-lines in FIG. 3), each hydraulic cylinder 91 being secured to a portion of the support frame 12 and having a portion pivotally secured to a portion of the conveyor support frame 80. The hydraulic cylinders 91 are thus connected to actuatingly lower the conveyor assembly 76 a predetermined distance, in one actuated position thereof, and to actuatingly raise the conveyor assembly 76 a predetermined distance, in one other actuated position thereof. In this manner the angular orientation or elevation of the conveyor assembly 76 can be positioned at an optimum lowermost position, in some instances, to reduce the power consumed by the conveyor drive 86, during the operation of the excavator 10.

As shown in FIGS. 1, 2 and 3, supported on the cutting side 14 of the support frame 12, generally near the forward end 18 thereof, is a forward control console 92, and supported on the cutting side 14 of the support frame 12, generally near the rearward end 20 thereof, is a rearward control console 94. The forward control console 92 and the rearward control console 94 are each, more particularly, supported on a platform structure 96. In a preferred form, the forward control console 92 and the rearward control console 94 each contain substantially all of the manually-operated, control actuating elements to control various aspects of the excavator 10, and each is constructed and adapted such that an operator can easily control the excavator 10 from either the forward control console 92 or the rearward control console 94.

In a preferred form, when the excavator 10 is moving in the forward direction 40 and the forward portion 68 of the vertical earth removal assembly 66 has been positioned in the earth engaging position thereof, as shown in FIGS. 1, 2 and 3, the operator will control the excavator 10 utilizing the forward control console 92. Utilizing the forward control console 92 to control the excavator 10, the operator is in an optimum position to visually observe obstacles which might lie in the path of the excavator 10, the portion of earth being excavatingly engaged by the forward portion 68 of the vertical earth removal assembly 66 and the forward portion 62 of the horizontal earth removal assembly 60, the excavated earth being moved generally onto the receiving end portion 82 of the conveyor 78, and the excavated earth moved along the conveyor 78 generally toward the disposing end 84 thereof to be deposited thereover. When the excavator 10 is moving in the forward direction 40 the operator utilizing the forward control console 92 is thus able to visually observe the operation of the various assemblies and apparatus aspects of the excavator 10 from an optimum vantage point.

Conversely, when the excavator 10 is being moved in the rearward direction 42, an operator utilizing the rearward control console 94 to control the various apparatus and assemblies of the excavator 10 is also positioned to observe the portion of earth being excavatingly engaged by the rearward portion 70 of the vertical earth removal assembly 66 and the rearward portion 64 of the horizontal earth removal assembly 60, the excavated earth being removed onto the conveyor 78, the

excavated earth being moved generally along the conveyor 78 generally toward the disposing end 84 thereof and deposited thereover, and obstacles which might lie in the path of the excavator 10. It should be particularly noted, however, that the excavator 10 can be operated from a single control console or by utilizing either the forward control console 92 or the rearward control console 94 when the excavator 10 is moving in the forward direction 40 and the rearward direction 42.

As shown in FIGS. 1, 2 and 3, a pair of power fluid reservoirs 98 are supported on a portion of the support frame 12, one of the power fluid reservoirs 98 being supported generally near the rearward end 20 of the support frame 12, and the other power fluid reservoir 98 being supported generally near the forward end 18 of the support frame 12. Each power fluid reservoir 98 is sized to retain a predetermined amount of power fluid which is subsequently utilized to drive or control various assemblies, components and apparatus of the excavator 10, during the operation of the excavator 10, as will be described in greater detail below.

Operation of the Preferred Embodiment

The excavator 10 is constructed to excavatingly engage and remove a predetermined portion of earth from a hill or bank-like earth structure in a more efficient, and in a more economical manner. Utilizing the grade and slope control apparatus, mentioned above, the operator will initially position the excavator 10, with respect to a horizontal plane, so that the horizontal earth removal assembly 60 and the vertical earth removal assembly 66 will each excavatingly engage and remove a portion of earth in a manner conforming to the preset, controlled grade and slope. It should be particularly mentioned, at this point, that the grade and slope control apparatus of the excavator 10, in a preferred form, has a portion which is connected to be actuated by the operator to control the grade, and another portion which is constructed to be automatically actuated, in response to a predetermined slope signal, thereby maintaining the excavator 10 in a controlled position wherein the horizontal earth removal assembly 60 and the vertical earth removal assembly 66 will excavatingly remove a portion of earth in accordance with the preset slope control signal, in a manner and for reasons which will be made more apparent below.

For the purpose of describing the operation of the excavator 10, it will be assumed that the excavator 10 is to be initially positioned near a bank-like earth structure to excavatingly engage a portion thereof while moving in a forward direction 40. After the excavator 10 has been initially positioned generally adjacent to the bank-like structure, the operator will actuate the forward positioning assembly 72, to position the forward portion 68 of the vertical earth removal assembly 66 in an earth engaging position, as shown in FIGS. 1 and 2, and will actuate the rearward actuating assembly 74 to move the rearward portion 70 of the vertical earth removal assembly 66 to the storage position thereof.

The operator will then actuate the conveyor control apparatus 90 to automatically adjust the tension of the conveyor 78 to a predetermined unloaded tension thereof. The conveyor control apparatus 90 is constructed to automatically maintain a predetermined alignment of the conveyor 78, during the operation of

the excavator 10, in a manner which will be described in greater detail below.

Diagrammatically shown in FIG. 4, and designated by the general reference numeral 100, is a cross-section of a hill or bank-like structure, which will be referred to below for the purpose of more clearly describing the operation of the excavator 10. Thus, the excavator 10 will be positioned generally adjacent the bank-like earth structure 100 in a position wherein the forward portion 62 of the horizontal earth removal assembly 60 will be positioned to excavatingly engage and remove a portion of the bank-like earth structure 100, designated in FIG. 4 by the general reference numeral 102 and referred to below as a "horizontal section of earth structure", for the purpose of clarity of description. Also, in this position of the excavator 10, the forward portion 68 of the vertical earth removal assembly 66 is positioned adjacent to the bank-like structure 100 to excavatingly engage and remove a portion of earth, designated in FIG. 4 by the general reference numeral 104 and referred to generally below as a "vertical section of earth structure", for the purpose of clarity of description.

As the excavator 10 is driven in a forward direction 40 to excavatingly engage and remove the horizontal section of earth structure 102 and the vertical section of earth structure 104, the excavated earth will be guidingly moved to the receiving end 82 of the conveyor 78. In an operating position of the excavator 10, the conveyor 78 is being continually driven by the conveyor drive 86 and, thus, the excavated earth moved onto the receiving end 82 of the conveyor 78 will be continually moved generally up the conveyor 78 toward the disposing end 84 thereof, and dropped or deposited thereover in a predetermined position as, for example, in the bed of a truck to be subsequently removed to a land fill or other such remote location.

When the excavator 10 has been moved in a forward direction 40 a predetermined distance to complete one pass along the bank-like earth structure 100, the operator will stop the excavator 10, and position the excavator 10 to make a subsequent pass along the bank-like earth structure 100. The operator will initially move the excavator 10 in a forward direction 40, a distance generally beyond the bank-like earth structure 100, prior to making a subsequent or second pass along the bank-like structure 100 in the rearward moving direction 42 of the excavator 10.

To position the excavator 10 to excavatingly engage the bank-like earth structure 100 in a rearward moving direction 42 thereof, the operator will actuate the forward positioning assembly 72, to position the forward portion 68 of the vertical earth removal assembly 66 to a storage position thereof, and will actuate the rearward positioning assembly 74 to move the rearward portion 70 of the vertical earth removal assembly 66 to an earth engaging position thereof. The operator will then maneuver the excavator 10 in a rearward direction to a position generally adjacent to the bank-like structure 100, wherein the rearward portion 64 of the horizontal earth removal assembly 60 is disposed to excavatingly engage a horizontal section of the earth structure, designated in FIG. 4 by the reference numeral 102a, and to a position wherein the rearward portion 70 of the vertical earth removal assembly 66 is disposed to excavatingly engage a vertical section of the structure, designated in FIG. 4 by the reference nu-

meral 104a. The excavator 10 will then be moved in the rearward direction 42 to excavate the horizontal section of earth structure 102a and to excavate the vertical section of earth structure 104a.

After the excavator 10 has been moved in the rearward direction 42 a sufficient distance to complete the second pass along the bank-like structure 100, the operator will again actuate the forward positioning assembly 72 and the rearward positioning assembly 74, to move the forward portion 68 of the vertical earth removal assembly 66 to an earth engaging position, and to move the rearward portion 70 of the vertical earth removal assembly 66 to a storage position, and will maneuver the excavator 10, in a manner as described before, to excavatingly engage the bank-like earth structure 100 in a forward moving direction 40 of the excavator 10.

The operation, generally described above, is repeated a predetermined number of times until the required portion of earth has been excavatingly removed. If, for example, a particular job specification requires the bank-like earth structure 100 to be excavated to a position generally designated in FIG. 4 by the general reference numeral 106, the excavator 10 will be excavatingly moved in a forward direction 40 and in a rearward direction 42 to excavatingly remove the horizontal sections of earth structure 102, 102a, 102b and 102c, and to excavatingly remove the vertical sections of earth structure 104, 104a, 104b and 104c.

The conveyor assembly 76 is disposed on the excavator 10 to receive the excavated earth moved thereon and move the excavated earth generally over the disposing end 84 thereof in a forward moving direction 40 of the excavator 10 and in a rearward moving direction 42 of the excavator 10, as mentioned before. Thus, virtually the only control adjustments which must be made by the operator, after each excavating pass along the bank-like earth structure 100, are to actuate the forward positioning assembly 72 and the rearward positioning assembly 74 to position the vertical earth removal assembly 66 to the proper earth engaging position, prior to making a subsequent excavating pass along the bank-like earth structure 100 in the forward moving direction 40 or the rearward moving direction 42 of the excavator 10, and, of course, to reverse the direction in which each of the endless track members 23 is driven.

Thus, the excavator 10 is constructed to be positioned to make subsequent excavating passes along the bank-like earth structure 100, in a faster, more efficient, more economical manner, and in a manner substantially eliminating the need for maneuvering the earth working apparatus to the initial starting position (which in many instances would be a considerable distance from the terminating position) or, in the alternative, eliminating the need for turning the earth working apparatus 180 degrees prior to making subsequent passes along the bank-like earth structure 100. The conveyor assembly 76 is supported on the excavator 10, and is disposed with respect to the horizontal earth removal assembly 60 and the vertical earth removal assembly 66 to receive the excavated earth deposited thereon and to move same to a predetermined disposing area, in a forward moving direction 40 and a rearward moving direction 42 of the excavator 10, in such a manner that the conveyor assembly 76 remains in a predisposed position, thereby eliminating the necessity

for reorienting an earth removal apparatus to receive and remove excavated earth prior to utilizing the excavator 10 to make subsequent excavating passes.

It should also be noted that, during the operation of the excavator 10, the grade and slope apparatus maintains the excavator 10 or, in other words, the support frame 12, in a predetermined grade and slope position with respect to a horizontal plane by automatically actuating the first forward hydraulic cylinders 44, 46 and 48, the second forward hydraulic cylinder 50, the first rearward hydraulic cylinders 52, 54 and 56, and the second rearward hydraulic cylinder 58.

Horizontal and Vertical Earth Removal Assembly

The horizontal earth removal assembly 60, more particularly, includes a forward horizontal digging implement 110 which is connected to the cutting side 14 of the support frame 12 or, more particularly, to a lowermost portion of the forward portion 62 thereof. The forward horizontal digging implement 110 basically includes a plurality of digging teeth 112, as shown more clearly in FIGS. 1 and 3. The digging teeth 112 are horizontally disposed in a spaced relationship along a lowermost end portion of a forward earth lifting member 114. The forward earth lifting member 114 is connected to the cutting side 14 of the support frame 12, and is disposed on an inclined plane, oriented such that the portion of earth engaged thereby, in a forward moving direction 40 of the excavator 10, is moved generally up the inclined plane and over the upper end thereof, during the operation of the excavator 10.

The rearward portion 64 of the horizontal earth removal assembly 60 includes a rearward horizontal digging implement 116, which is connected to the cutting side 14 of the support frame 12 or, more particularly, to a lowermost portion of the rearward portion 64 thereof. The rearward horizontal digging implement 116, as shown more clearly in FIGS. 1 and 3, basically includes a plurality of digging teeth 118. The digging teeth 118 are, more particularly, horizontally disposed in a spaced relationship along a lowermost portion of the rearward earth lifting member 120. The rearward earth lifting member 120 is also connected to the cutting side 14 of the support frame 12 and is disposed on an inclined plane, oriented such that the portion of earth engaged thereby, in a rearward moving direction 42 of the excavator 10 is moved generally up the inclined plane and over the upper end thereof, during the operation of the excavator 10.

The uppermost end of the forward earth lifting member 114 and the rearward earth lifting member 120 are spaced a distance apart and connected via a horizontally disposed plate 122, as shown more clearly in FIGS. 1 and 3. More particularly, the forward earth lifting member 114 and the rearward earth lifting member 120 are spaced a predetermined distance apart such that the receiving end portion 82 of the conveyor assembly 76 can be operatingly disposed therebetween. Thus, the receiving end 82 of the conveyor assembly 76 is disposed between the forward earth lifting member 114 and the rearward earth lifting member 120, to receive the excavated earth therefrom in a forward moving direction 40 and in a rearward moving direction 42 of the excavator 10.

The forward earth lifting member 114 and the rearward earth lifting member 120, each extend a predetermined distance from the cutting side 14 of the support

frame 12, terminating with an outermost portion 124. The outermost portion 124 of the forward earth lifting member 114 and the rearward earth lifting member 120 are each connected via a vertically disposed plate 126, as shown more clearly in FIGS. 1 and 2. The plate 126, not only provides additional structural support for the horizontal earth removal assembly 60, but also provides a baffle which prevents the excavated earth from being moved generally under the horizontal earth removal assembly 60, and thus cooperates to guide the excavated earth onto the receiving end 82 of the conveyor 78.

More particularly, the forward earth lifting member 114 and the rearward earth lifting member 120, each extend a distance 128 from the support frame 12, which defines the width of the horizontal section of earth structure excavatingly removed by the forward horizontal digging implement 110 and the forward earth lifting member 114 associated therewith, in a forward moving direction 40 of the excavator 10, and the width of the horizontal section of earth structure excavatingly removed by the rearward horizontal digging implement 116 and the rearward earth lifting member 120 associated therewith, in a rearward moving direction 42 of the excavator 10, as shown more clearly in FIG. 3 and as diagrammatically shown in FIG. 4 with respect to the horizontal section of earth structure 102b.

The height or the vertical distance 130 generally between the upper end and the lower end of the forward earth lifting member 114 and the rearward earth lifting member 120, as shown more clearly in FIGS. 1 and 2, defines the vertical height of the horizontal section of earth structure excavatingly removed by the forward earth lifting member 114 and the forward horizontal digging implement 116 connected thereto, and the rearward earth lifting member 120 and the rearward horizontal digging implement 116 connected thereto, in a forward moving direction 40 and in a rearward moving direction 42, respectively, of the excavator 10. The vertical height of the horizontal section of earth structure removed by the horizontal earth removal assembly 60, as described above, is diagrammatically shown in FIG. 4 with respect to the horizontal section of earth structure 102b. In a preferred form, the horizontal earth removal assembly 60 is constructed such that the vertical height 130 of the horizontal section of earth structure excavatingly removed thereby is maintained at a minimum predetermined vertical height, the minimum predetermined vertical height being that vertical height sufficient for the conveyor assembly 76 to be operatively disposed between the forward earth lifting member 114 and the rearward earth lifting member 120, as described before. In this manner, less power is consumed by the excavator 10 per cubic yard of earth excavated, since the maximum amount of earth is excavated by the vertical earth removal assembly 66 wherein such excavated earth is aided by gravity in falling onto the conveyor assembly 76.

As shown more clearly in FIGS. 1 and 2, the excavator 10 also includes a forward baffle member 132, having an upper end 134 and a lower end 136. The forward baffle member 132 is connected to one side of the forward earth lifting member 114, generally opposite the outermost portion 124 thereof, and has a portion thereof which extends a distance generally from the forward earth lifting member 114 toward the forward

end 18 of the support frame 12. The lower end 136 of the forward baffle member 132 is disposed in a horizontal plane, generally coplanar with the lower end portion of the horizontal earth removal assembly 60, and the upper end 134 of the forward baffle member 132 extends a distance vertically above the forward earth lifting member 114. The forward baffle member 132 is thus sized and positioned to cooperate with the forward earth lifting member 114 to channel a portion of the excavated earth generally up the forward earth lifting member 114 and onto the receiving end 82 of the conveyor 78.

The excavator 10 also includes a rearward baffle member 138, having an upper end 140 and a lower end 142, as shown more clearly in FIGS. 1 and 2. The rearward baffle member 138 is connected to one side of the rearward earth lifting member 120, generally opposite the outermost portion 124 thereof, and has a portion thereof which extends a distance generally from the rearward earth lifting member 120 toward the rearward end 20 of the support frame 12. The lower end 142 of the rearward baffle member 138 is substantially coplanar with the lowermost portion of the horizontal earth removal assembly 60, and the upper end 140 of the rearward baffle member 138 extends a distance vertically above the rearward earth lifting member 120. The rearward baffle member 138 is thus sized and shaped to cooperate with the rearward earth lifting member 120 to channel a portion of the excavated earth generally up the rearward earth lifting member 120 and onto the receiving end 82 of the conveyor 78.

The vertical earth removal assembly 66 includes a forward vertical digging implement 150 which is connected to the cutting side 14 of the support frame 12. The forward vertical digging implement 150 basically includes a plurality of spaced digging teeth 152 which are constructed and disposed to excavatingly engage a portion of earth generally along a predetermined vertical plane, in a forward moving direction 40 of the support frame 12, as shown more clearly in FIGS. 1 and 2.

The vertical earth removal assembly 66 also includes a rearward digging implement 154 which is connected generally to the cutting side 14 of the support frame 12. As shown more clearly in FIGS. 1 and 2, the rearward digging implement 154 also basically includes a plurality of spaced digging teeth 156 which are constructed and disposed to excavatingly engage a portion of earth, generally along a predetermined vertical plane, in a rearward moving direction 42 of the support frame 12.

The forward digging implement 150 and the rearward digging implement 154 are, more particularly, connected to a forward frame 158 and a rearward frame 160, respectively. The forward frame 158 and the rearward frame 160 each include an earth engaging face 162, an upper end 164, a lower end 166, a cutting side 168 and a pivot side 170. The forward vertical digging implement 150 is, more particularly, connected to the cutting side 168 of the forward frame 158, and the rearward digging implement 154 is, more particularly, connected to the cutting side 168 of the rearward frame 160.

As shown more clearly in FIG. 3, the pivot side 170 of the forward frame 158 is pivotally secured to the cutting side 14 of the support frame 12 via a pivot member 172, and the pivot side 170 of the rearward frame 160 is pivotally secured to the cutting side 14 of the support frame 12 via a pivot member 174. The forward frame

158 is thus pivotable in a pivot direction 176 and in a pivot direction 178, generally about the pivot member 172, and the rearward frame 160 is pivotable in a pivot direction 180 and in a pivot direction 182, generally about the pivot member 174. More particularly, the forward frame 158 and the rearward frame 160 are each pivotable to an earth engaging position and to a storage position, in a manner and for reasons to be described in greater detail below.

As shown more clearly in FIG. 2, the forward frame 158 is sized and pivotably supported on the support frame 12 such that the lower end 166 thereof is disposed in a predetermined horizontal plane, which is substantially coplanar with the upper end of the rearward earth lifting member 120, yet allowing a clearance therebetween so that the forward frame 158 and the forward vertical digging implement 150 connected thereto can be pivotally moved generally above the upper end of the rearward earth lifting member 120 to an earth engaging position, as shown in FIGS. 1, 2 and 3, and to a storage position as shown in FIGS. 1, 2 and 3, with respect to the rearward frame 160. The rearward frame 160 is also sized and pivotably supported on the support frame 12 such that the lower end 166 thereof is disposed in a predetermined horizontal plane, substantially coplanar with the upper end of the forward earth lifting member 114, yet allowing a clearance therebetween for the rearward frame 160 and the rearward digging implement 154 to be pivoted generally over the upper end of the forward earth lifting member 114, to an earth engaging position, as shown in FIGS. 1, 2 and 3, with respect to the forward frame 158, and to a storage position, as shown in FIGS. 1, 2 and 3.

The width of the forward frame 158 and the rearward frame 160, generally between the pivot side 170 and the cutting side 168 of each of the frames 158 and 160, is sized to support the forward digging implement 150 and the rearward digging implement 154, respectively, in a predetermined vertical cutting plane, substantially coplanar with the outermost portions 124 of the forward earth lifting member 114 and the rearward earth lifting member 120. The distance 184 between the forward vertical digging implement 150 and the rearward vertical digging implement 154 and the outermost portions 124, described above, is shown more clearly in FIG. 3 with respect to the forward frame 158.

The distance 184, more particularly, defines the width of the vertical section of earth structure excavatingly removed by the forward vertical digging implement 150 and the rearward digging implement 154 when such vertical digging implement 150 and 154 has been pivoted to the earth engaging position, as shown in FIGS. 1, 2 and 3, with respect to the forward vertical digging implement 150. The width 184 of the portion of earth excavatingly engaged by the forward vertical digging implement 150 or rearward vertical digging implement 154 is diagrammatically shown in FIG. 4, with respect to the vertical section of earth structure 104b.

The vertical distance, generally between the upper end 164 and the lower end 166 of the forward frame 158 and the forward digging implement 150 connected thereto, and the rearward frame 160 and the rearward digging implement 154 connected thereto defines substantially the height of the vertical section of earth structure removed by the vertical earth removal assembly 66, in a forward moving direction 40 and in a rear-

ward moving direction 42 of the excavator 10. In a preferred form, and, as mentioned before, the vertical height of the forward frame 158 and the rearward frame 160 is sized such that the vertical earth removal assembly 66 excavatingly engages and removes a maximum portion of the earth excavated during each pass of the excavator 10 moving in a forward direction 40 and in a rearward direction 42, thereby reducing the power consumed by the excavator 10 per cubic yard of earth excavated.

It should also be noted that the lower end 166 of the forward frame 158 is shaped to be pivotally moved over the upper end 140 of the rearward baffle member 138 to a storage position wherein the earth engaging face 162 thereof is substantially coplanar with the rearward baffle member 138, thereby cooperating with the rearward baffle member 138 to channel a portion of the excavated earth onto the conveyor 78. The lower end 166 of the rearward frame 160 is shaped to be pivotally moved over the upper end 134 of the forward baffle member 132 to a storage position of the rearward frame 160 wherein the earth engaging face 162 thereof is substantially coplanar with the forward baffle member 132, thereby cooperating with the forward baffle member 132 to channel a portion of the excavated earth onto the conveyor 78.

As mentioned before, the vertical earth removal assembly 66 includes a forward positioning assembly 72 and a rearward positioning assembly 74, each of which are constructed to position a portion of the vertical earth removal assembly 66 in an earth engaging position or in a storage position. The forward positioning assembly 72 and the rearward positioning assembly 74 are constructed similar and each includes a hinge member pivotally connecting the vertical earth removal assembly 66 to the support frame 12, and a hydraulic cylinder actuator connected to the support frame 12 and to the hinge member, in such a manner that the forward portion 68 and the rearward portion 70 of the vertical earth removal assembly 66 can each be selectively positioned in an earth engaging position or in a storage position, during the operation of the excavator 10.

The forward positioning assembly 72 includes a first hinge member 188, having one side thereof pivotally secured to a portion of the forward frame 158 via a pivot member 190, generally along a face thereof, opposite the earth engaging face 162, as shown more clearly in FIG. 3. A second hinge member 192 has one side thereof pivotally secured to the side of the first hinge member 188, generally opposite the side thereof which is pivotally secured to the forward frame 158, via a pivot member 194. The side of the second hinge member 192, generally opposite the side thereof pivotally secured to the first hinge member 188, is pivotally secured to the cutting side 14 of the support frame 12 via a pivot member 196.

The forward positioning assembly 72, as shown more clearly in FIGS. 3 and 5, also includes a pair of hydraulic cylinders 198 and 200. Each hydraulic cylinder 198 and 200 has a portion thereof which is pivotally connected to the support frame 12, and a rod member 202 which is reciprocatingly disposed therein. The end of each rod member 202, opposite the end thereof which is reciprocatingly disposed in one of the hydraulic cylinders 198 and 200, is pivotally secured to a portion of the second hinge member 192, for reasons which will be made more apparent below.

The rearward positioning assembly 74 includes a first hinge member 204, as shown more clearly in FIG. 3, which is pivotally secured to a portion of the rearward frame 160, generally along a face, opposite the earth engaging face 162 thereof, via a pivot member 206. One side of a second hinge member 208 is pivotally secured to the side of the first hinge member 204, opposite the side thereof pivotally secured to the rearward frame 160, via a pivot member 210. The side of the second hinge member 208, opposite the side thereof which is pivotally secured to the first hinge member 204, is pivotally secured to the cutting side 14 of the support frame 12 via a pivot member 212.

The rearward positioning assembly 74 also includes a pair of hydraulic cylinders 214 and 216, a portion of each hydraulic cylinder 214 and 216 being pivotally secured to a portion of the support frame 12, as shown more clearly in FIG. 5. Each hydraulic cylinder 214 and 216 has a rod member 218 reciprocatingly disposed therein, and the end of each rod member, opposite the end thereof reciprocatingly disposed in one of the hydraulic cylinders 214 or 216, is pivotally secured to a portion of the second hinge member 208, as shown in FIGS. 2 and 5.

The hydraulic cylinders 198 and 200 of the forward positioning assembly 72 and the hydraulic cylinders 214 and 216 of the rearward positioning assembly 74, each have one actuated position wherein the rod member 202 or 218 disposed therein is reciprocatingly extended therefrom in a general direction 220, as shown in FIG. 5, and one other actuated position wherein the rod members 202 and 218 reciprocatingly disposed therein are moved in a general direction 222, as shown more clearly in FIG. 5. When the hydraulic cylinders 198 and 200 of the forward positioning assembly 72 are actuated to move the rod members 202 in a direction 220, the second hinge member 192 connected thereto will be moved in a direction generally away from the cutting side 14 of the support frame 12, thereby pivoting the forward frame 158 in a pivot direction 176, generally toward an earth engaging position thereof, as shown in FIGS. 1, 2 and 3.

The first hinge member 188 and the second hinge member 192 are each sized and pivotally connected, and the hydraulic cylinders 198 and 200 are each positioned such that the first hinge member 188 and the second hinge member 192 are positioned in a substantially coplanar relationship, in an earth engaging position of the forward vertical digging implement 150, as shown in FIGS. 1, 2 and 3. In this manner, the digging load imposed on the forward digging implement 150 and the forward frame 158, as the excavator 10 is being moved in a generally forward direction 40, will be transmitted through the first hinge member 188 and the second hinge member 192 and carried therethrough by the support frame 12. Thus, the digging load is, for the most part, not imposed on the hydraulic cylinders 198 and 200, thereby decreasing the size requirements of the hydraulic cylinders 198 and 200, and substantially decreasing the wearing thereof and reducing the maintenance downtime for repair or replacement thereof.

The first hinge member 204 and the second hinge member 208 are also each sized and pivotally connected, and the hydraulic cylinders 214 and 216 are each positioned such that the first hinge member 204 and the second hinge member 208 are positioned in a substantially coplanar relationship, in an earth engag-

ing position of the rearward digging implement 154, in a manner similar to that described above with respect to the first hinge member 188 and the second hinge member 192. The digging load imposed on the rearward digging implement 154 and the rearward frame 160, as the excavator 10 is being moved in a generally rearward direction 42, is thus transmitted through the first hinge member 204 and the second hinge member 298 and carried therethrough by the support frame 12, thereby decreasing the size requirements of the hydraulic cylinders 214 and 216, and decreasing the wearing thereof and reducing the maintenance downtime for the excavator 10.

The conveyor drive 86 includes a pair of hydraulic motors 230, one hydraulic motor being connected to one end of the conveyor drive shaft 88 and the other hydraulic motor 230 being connected to the opposite end of the conveyor drive shaft 88. More particularly, one end of the conveyor drive shaft 88 extends through a slot 232 (one slot 232 being shown in FIG. 1) formed through one side of the conveyor support frame 80, and the opposite end of the conveyor drive shaft 88 extends through a similar slot (not shown) formed through the opposite side of the conveyor support frame 80.

A first hydraulic cylinder 240 and a second hydraulic cylinder 242 are each connected to the conveyor support frame 80. Each of the piston rods of the first and the second hydraulic cylinders 240 and 242 is connected to one of the hydraulic motors 230.

In a preferred form, the conveyor 78 is securedly supported in a stationary position relative to the conveyor support frame 80 generally near the receiving end 82 of the conveyor 78. Thus, as the conveyor 78 is moved in a tension increasing direction 236 by so moving the conveyor drive shaft 88, the tension imposed on the conveyor 78 will be increased and, as the conveyor 78 is moved in a tension decreasing direction 238 by so moving the conveyor drive shaft 88, the tension imposed on the conveyor 78 will be increasingly decreased. It should be noted that, in one other form, the end of the conveyor 78 which is in driving engagement with the hydraulic motors 230 could be stationarily positioned, and the conveyor control apparatus 90 could be connected to the opposite end of the conveyor 78, which would be movably supported via a shaft extending through slots, similar to the slots 232 and 234.

A conveyor and conveyor control apparatus constructed in a manner generally having a portion sensibly engaging a portion of the conveyor 78 and automatically aligning the conveyor 78 to predetermined alignment positions and one other position connected to the conveyor 78 automatically adjusting the tension of the conveyor 78 to predetermined tension positions are described in detail in the Applicants' U.S. Pat. No. 3,778,912, and a detailed description is not required herein.

Grade and Slope Control

Schematically and diagrammatically shown in FIG. 6 is the grade and slope control 350 which is utilized to controllingly position the support frame 12 of the excavator 10 in predetermined grade and slope positions and to automatically maintain a preset or predetermined slope position of the support frame 12, during the operation of the excavator 10, as described generally before. The hydraulic cylinders 44, 46, 48, 50, 52, 54, 56 and 58, described before, are schematically

shown in FIG. 6 and, in one sense, are included in the grade and slope control 350. Each hydraulic cylinder 44, 46, 48, 50, 52, 54, 56 and 58, sometimes referred to below as a vertical positioning apparatus, is connected to the track assembly 22 and to the support frame 12, for raising the support frame 12 in a generally vertically upwardly direction, in one actuated position thereof, and lowering the support frame 12 in a generally vertically downwardly direction, in one other actuated position thereof. Thus, the grade and slope control 350 generally includes a vertical positioning apparatus 352 and a grade and slope actuator 354, the grade and slope actuator 354 being connected to the vertical positioning apparatus 352 to automatically actuate the vertical positioning apparatus 352 to raise and lower the support frame 12 at predetermined control positions, thereby positioning the support frame 12 in predetermined grade and slope positions, in a manner which will be described in greater detail below.

As shown in FIG. 6, the first forward hydraulic cylinders 44, 46 and 48, have the upper portions thereof connected in hydraulic parallel via a pair of conduits 356 and 358. More particularly, the upper portions of the first forward hydraulic cylinders 44 and 46 are connected via the conduit 356, and the first forward hydraulic cylinders 44 and 46 are connected in hydraulic parallel with the first forward hydraulic cylinder 48 via the interconnecting conduit 358. The lower portions of the first forward hydraulic cylinders 44, 46 and 48 are also connected in hydraulic parallel by a pair of conduits 360 and 362. More particularly, the conduit 360 connects the lower portions of the first forward hydraulic cylinders 44 and 46, and the conduit 362 is connected to the conduit 360 on one end thereof and to the lower portion of the first hydraulic cylinder 48, as shown in FIG. 6.

A conduit 364 is connected on one end thereof to the conduit 358 to provide a common inlet or discharge for power fluid to flow therethrough to the upper portions of the first forward hydraulic cylinders 44, 46 and 48, in one position of the grade and slope control 350. A conduit 366 is connected on one end thereof to the conduit 362 to provide a common inlet or discharge for the power fluid to flow therethrough to the lower portions of the first forward hydraulic cylinders 44, 46 and 48, during the operation of the grade and slope control 350, as will be described in greater detail below.

The upper portions of the first rearward hydraulic cylinders 52, 54 and 56 are connected in hydraulic parallel, in a manner similar to that described above with respect to the first hydraulic cylinders 44, 46 and 48, via a pair of conduits 368 and 370, the conduit 370 being connected on one end thereof to the conduit 368 and on the opposite end thereof to the upper portion of the first rearward hydraulic cylinder 56.

The lower portions of the rearward hydraulic cylinders 52, 54 and 56 are also connected in hydraulic parallel via a pair of conduits 372 and 374, the conduit 374 being connected on one end thereof to the conduit 372 and on the opposite end thereof to the lower portion of the first rearward hydraulic cylinder 56.

A conduit 376 is connected on one end thereof to the conduit 370 to provide a common inlet and discharge conduit for the power fluid to flow therethrough to the upper portions of each of the first rearward hydraulic cylinders 52, 54 and 56. A conduit 378 is connected on one end thereof to the conduit 374 to provide a com-

mon inlet or discharge for the power fluid to flow therethrough to the lower portions of the first rearward hydraulic cylinders 52, 54 and 56 during the operation of the grade and slope control 350, as will be described in greater detail below.

As shown in FIG. 6, the upper portion of the second forward hydraulic cylinder 50 and the upper portion of the second rearward hydraulic cylinder 58 are connected in hydraulic parallel via a conduit 380, and the lower portion of the second forward hydraulic cylinder 50 and the lower portion of the second rearward hydraulic cylinder 58 are connected in hydraulic parallel via a conduit 382.

A conduit 384 is connected on one end thereof to the conduit 382 to provide a common inlet or discharge for the power fluid to flow therethrough to the lower portion of the second forward hydraulic cylinder 50 and the second rearward hydraulic cylinder 58. A conduit 386 is connected on one end thereof to the conduit 380 to provide a common inlet or discharge for the power fluid to flow therethrough to the upper portions of the second forward hydraulic cylinder 52 of the second forward hydraulic cylinder 58 during the operation of the grade and slope control apparatus 350, as will be described in greater detail below.

The grade and slope control 350 includes a power fluid supply 390, schematically represented in FIG. 6 as three separate pumps 390, for the purpose of clarity of description. It should be expressly understood that the power fluid supply 390, or in other words, the pumps 390, as shown in FIG. 6, actually represent a supply or source of pressurized power fluid, and could be three separate sources, in one form, or, in one other form, a single source. The grade and slope control 350 also includes a power fluid reservoir 392 to retain a predetermined volume of power fluid for the operation of the grade and slope control 350.

The grade and slope control 350 includes a first control valve 394, having a first energized position, schematically indicated in FIG. 6 by the solid-arrows in the first control valve 394, and a second energized position, schematically indicated in FIG. 6 by the dashed-arrows in the first control valve 394. The first control valve 394 is interposed generally between the first forward hydraulic cylinders 44, 46 and 48 and the power fluid supply 390 and the power fluid reservoir 392, the power fluid supply 390 being connected to the first control valve 394 via a conduit 396, and the power fluid reservoir 392 being connected to the first control valve 394 via a conduit 398.

In the first energized position of the first control valve 394, the first control valve 394 is positioned to establish fluidic communication between the upper portions of the first forward hydraulic cylinders 44, 46 and 48 and the power fluid supply 390, to actuate the first forward hydraulic cylinders 44, 46 and 48 to an actuated raising position, thereby raising a portion of the support frame 12; and in the second energized position of the first control valve 394, the first control valve 394 is positioned to establish fluidic communication between the power fluid supply 390 and the lower portions of the first forward hydraulic cylinders 44, 46 and 48, to actuate the first forward hydraulic cylinders 44, 46 and 48 to an actuated lowering position, thereby lowering a portion of the support frame 12. Since the first forward hydraulic cylinders 44, 46 and 48 are connected in hydraulic parallel, the first forward hydraulic

cylinders 44, 46 and 48 will cooperate to raise and lower the support frame 12 about a single predetermined control position, which is located in the hydraulic center midway between the first forward hydraulic cylinders 44, 46 and 48.

A second control valve 400 is interposed generally between the power fluid supply 390 and the first rearward hydraulic cylinders 52, 54 and 56, the power fluid supply 390 being connected to the second control valve 400 via a conduit 402, and the power fluid reservoir 392 being connected to the second control valve 400 by a conduit 404. The second control valve 400 has a first energized position, schematically indicated in FIG. 6 by the solid-arrows in the second control valve 400, and a second energized position, schematically indicated in FIG. 6 by the dashed-arrows in the second control valve 400.

In the first energized position of the second control valve 400, fluidic communication is established between the power fluid supply 390 and the upper portions of the first rearward hydraulic cylinders 52, 54, and 56 to actuate the first rearward hydraulic cylinders 52, 54 and 56 to an actuated raising position, thereby raising a portion of the support frame 12; and in the second energized position of the second control valve 400, fluidic communication is established between the power fluid supply 390 and the lower portions of the first rearward hydraulic cylinders 52, 54 and 56 to actuate the first rearward hydraulic cylinders 52, 54 and 56 to an actuated lowering position, thereby lowering a portion of the support frame 12. Since the first rearward hydraulic cylinders 52, 54 and 56 are connected in hydraulic parallel, the first rearward hydraulic cylinders 52, 54 and 56 will cooperate to raise and lower the support frame 12 about a single predetermined control position which is disposed in the hydraulic center, midway between the first rearward hydraulic cylinders 52, 54 and 56.

A third control valve 406, as shown in FIG. 6, having a first energized position, shown schematically by the solid-arrows in the third control valve 406, and a second energized position, shown schematically by the dashed-arrows in the third control valve 406, is interposed generally between the second forward hydraulic cylinder 50 and the second rearward hydraulic cylinder 58 and the power fluid supply 390. The power fluid supply 390 is connected to the third control valve 406 via a conduit 408, and the power fluid reservoir 392 is connected to the third control valve 406 via a conduit 410. In the first energized position of the third control valve 406, fluidic communication is established between the power fluid supply 390 and the upper portion of the second forward hydraulic cylinder 50 and the second rearward hydraulic cylinder 58 to actuate the second forward hydraulic cylinder 50 and the second rearward hydraulic cylinder 58 to an actuated raising position, thereby raising a portion of the support frame 12; and in the second energized position of the third control valve 406, fluidic communication is established between the power fluid supply 390 and the lower portion of the second forward hydraulic cylinder 50 and the second rearward hydraulic cylinder 58 to actuate the second forward hydraulic cylinder 50 and the second rearward hydraulic cylinder 58 to an actuated lowering position, thereby lowering a portion of the support frame 12. Since the second forward hydraulic cylinder 50 and the second rearward hydraulic cylinder 58

are connected in hydraulic parallel, the second forward hydraulic cylinder 50 and the second rearward hydraulic cylinder 58 will cooperate to raise and lower the support frame 12 about a single predetermined control position, which is disposed in the hydraulic center, midway between the second forward hydraulic cylinder 50 and the second rearward hydraulic cylinder 58.

As shown in FIG. 6, the grade and slope control 350 includes an energized power supply 412 which is connected to the first control valve 394, the second control valve 400 and to the third control valve 406 to provide energizing power thereto when in electrical communication therewith. A first switch 414 is interposed between the first control valve 394 and the energizing power supply 412. The first switch 414 includes a switch arm 416, movable to a first position 418 and a second position 420. A switch actuator 422 is connected to the first switch 414 to move the switch arm 416 thereof to the first position 418 and to the second position 420, in an actuated position thereof.

In the disconnect position of the first switch 414, the first switch 414 interrupts the electrical communication between the energizing power supply 412 and the first control valve 394, thereby de-energizing the first control valve 394. When the switch actuator 422 is actuated to move the switch arm 416 to the first position 418, the first switch 414 establishes electrical communication between the energizing power supply 412 and the first control valve 394 via a pair of conductors 426 and 428, thereby energizing the first control valve 394 to the first energized position thereof. When the switch actuator 422 is actuated to move the switch arm 416 to the second position 420, the first switch 414 establishes electrical communication between the energizing power supply 412 and the first control valve 394 via the conductor 426 and a conductor 430, thereby energizing the first control valve 394 to the second energized position thereof.

A second switch 432 is interposed generally between the second control valve 400 and the energizing power supply 412. The second switch 432 is constructed similar to the first switch 414 and includes a switch arm 434 movable to a first position 436 and a second position 438. A switch actuator 440 is connected to the switch arm 434 of the second switch 432 to move the switch arm 434 to the disconnect position of the second switch 432, that is a position wherein the switch 432 interrupts the electrical communication between the energizing power source 412 and the second control valve 400, thereby de-energizing the second control valve 400. The switch actuator 440 is also constructed to move the switch arm 434 to the first position 436, thereby establishing electrical communication between the energizing power source 412 and the second control valve 400 via the conductor 426 and a conductor 442, thereby energizing the second control valve 400 to the first energized position thereof. The switch actuator 440 is also constructed to move the switch arm 434 to the second position 438 wherein the second switch 432 establishes electrical communication between the energizing power source 412 and the second control valve 400 via the conductor 426 and a conductor 444, thereby energizing the second control valve 400 to the second energized position thereof.

A third switch 446 is interposed generally between the third control valve 406 and the energizing power supply 412. The third control switch 446 has a discon-

nect position wherein the electrical communication between the energizing power supply 412 and the third control valve 406 is interrupted, thereby de-energizing the third control valve 406; a first position wherein electrical communication is established between the energizing power supply 412 and the third control valve 406 via the conductor 426 and a conductor 448 to energize the third control valve 406 to the first energized position thereof; and a second position where electrical communication is established between the energizing supply 412 and the third control valve 406 via the conductor 426 and the conductor 450 to energize the third control valve 406 to the second energized position thereof. Thus, the third switch 446 is, in one sense, constructed to energize the third control valve 406 in a functional manner, similar to that described before with respect to the first switch 414 and the second switch 432. More particularly, and, in a preferred form, the third switch 446 includes a differential amplifier 452, a level sensor 454 and a command signal source 456 and a signal selector 458, as shown in FIG. 6.

The level sensor 454 is positioned and supported on the support frame 12 of the excavator 10, and is constructed to sense the slope position of the support frame 12 with respect to a predetermined horizontal plane, and to provide an output signal 460 responsive to the sensed slope position of the support frame 12. The command signal source 456 is constructed to be preset to a predetermined slope level of the support frame 12, and has an output signal 462 responsive to the preset slope position.

The differential amplifier 452 is constructed to receive and compare the output signals 460 and 462 from the level sensor 454 and the command signal source 456, respectively, and has an output signal 464 responsive to the comparison of the output signals 460 and 462 of the level sensor 454 and the command signal source 456. The signal selector 458 is constructed to receive the output signal 464 from the differential amplifier 452 and to be switchingly positioned in a disconnect position, a first position and a second position, in response to the received output signal 464 of the differential amplifier 452. As shown in FIG. 6, the signal selector 458 is interposed between the energizing power supply 412 and the third control valve 406.

In one form, for example, the command signal source 456 could consist of a potentiometer connected to a power supply, such that by adjusting the potentiometer, the voltage level of the output signal 462 can be adjusted to a determinable level corresponding to a particular slope level setting of the support frame 12. The level sensor 454 can be of the pendulum-type having a portion connected to a potentiometer and a power supply in such a manner that as the pendulum is moved to indicate a change in the slope level on the support frame 12, the voltage level of the output signal 460 is correspondingly changed. The differential amplifier 452 is of a type well known in the art, and the output signal 464 thereof corresponds or is responsive to the comparison of the two output signals 460 and 462.

The signal selector 458, in one form, can include a pair of transistor operated type switches, one such switch being connected to the differential amplifier 452 to provide electrical communication between the power supply 412 and the third control valve 406, to energize the third control valve 406 to the first position

thereof, and one such switch being connected to the differential amplifier 452 to provide electrical communication between the power supply and the third control valve 406 to energize the third control valve 406 to the second energized position thereof. The switches are, of course, connected to selectively energize the third control valve 406 in the first energized position and in the second energized position in response to the output signal 464 of the differential amplifier 452.

The grade and slope control 350 is thus constructed such that the support frame 12 of the excavator 10 is vertically and automatically positionable about three predetermined control positions; two of the control positions being located generally near the cutting side 14 of the support frame 12, and the third control position being located generally near the earth removal side 16 of the support frame 12, and yet the excavator 10 is supported generally at the four-corner positions thereof. Thus, the grade and slope control 350 provides the maximum positionability for the support frame 12, without a loss of supporting integrity.

In one form, the first switch 414 and the second switch 432 may be of the toggle-switch type, such that each switch 414 and 432 can be manually positioned in the first position 418 and 436 or the second position 420 or 438 thereof, prior to initiating the operation of the excavator 10. In this manner, the grade level of the support frame 12 is manually set to a predetermined grade level, and, as mentioned before, and in a preferred form, the slope level of the support frame 12 is continually monitored and maintained by the third switch 446 during the operation of the excavator 10.

Changes may be made in the construction and the arrangement of the various parts or elements of the embodiment as disclosed herein without departing from the invention as defined in the following claims.

What is claimed is:

1. An excavator comprising:

a support frame, having a cutting side, an earth removal side, a forward end and a rearward end; drive means connected to the support frame for supporting the support frame and for moving the support frame in a forward direction and in a rearward direction;

earth removal means connected to the cutting side of the support frame for excavating earth in the forward direction and in the rearward direction of the support frame;

a grade and slope control automatically positioning the support frame and the earth removal means connected thereto in a predetermined slope position relative to a predetermined horizontal plane, comprising:

a vertical positioning assembly having a portion thereof connected to a portion of the drive means and another portion thereof connected to the support frame, the vertical positioning assembly raising the support frame in a generally vertically upwardly direction in one actuated position thereof, and lowering the support frame in a generally vertically downwardly direction, in one other actuated position thereof, comprising:

first forward hydraulic cylinder means disposed generally near the forward end and generally near the cutting side of the support frame, and being hydraulically connected to raise and to lower the support frame relative to a single pre-

determined control position, generally near the forward end and generally near the cutting side of the support frame;

second forward hydraulic cylinder means disposed generally near the forward end and generally near the earth removal side of the support frame;

first rearward hydraulic cylinder means disposed generally near the rearward end and generally near the cutting side of the support frame and being hydraulically connected for raising and lowering the support frame relative to a single predetermined control position generally near the rearward end and generally near the cutting side of the support frame;

second rearward hydraulic cylinder means disposed generally near the rearward end and generally near the earth removal side of the support frame, the second rearward hydraulic cylinder means connected in hydraulic parallel to the second forward hydraulic cylinder means for raising and lowering the earth removal side of the support frame relative to a single predetermined control position generally near the earth removal side of the support frame and generally between the forward end and the rearward end of the support frame;

a power fluid supply hydraulically connected to the first forward hydraulic cylinder means, the second forward hydraulic cylinder means, the first rearward hydraulic cylinder means and the second rearward hydraulic cylinder means supplying actuating power fluid thereto when in communication therewith; and,

a grade and slope actuator connected to the vertical positioning assembly actuating the vertical positioning assembly to elevate the support frame in a generally upwardly direction and in a generally downwardly direction, comprising:

a first control valve interposed between the first forward hydraulic cylinder means and the power fluid supply, having a first energized position establishing communication between the first forward hydraulic cylinder means and the power fluid supply actuating the first forward hydraulic cylinder means raising the support frame, and a second energized position establishing communication between the first forward hydraulic cylinder means and the power fluid supply actuating the first forward hydraulic cylinder means lowering the support frame;

a second control valve interposed between the first rearward hydraulic cylinder means and the power fluid supply, having a first energized position establishing communication between the first rearward hydraulic cylinder means and the power fluid supply actuating the first rearward hydraulic cylinder raising the support frame, and a second energized position establishing communication between the first rearward hydraulic cylinder means and the power fluid supply actuating the first rearward hydraulic cylinder lowering the support frame;

a third control valve interposed between the second forward hydraulic cylinder means, the second rearward hydraulic cylinder means and the power fluid supply, having a first energized po-

sition establishing communication between the second forward hydraulic cylinder means, the second rearward hydraulic cylinder means and the power fluid supply raising the support frame, and a second energized position establishing communication between the second forward hydraulic cylinder means, the second rearward hydraulic cylinder means and the power fluid supply lowering the support frame;

an energizing power supply connected to the first control valve, the second control valve, and the third control valve providing energizing power thereto when in communication therewith;

a first switch interposed between the first control valve and the energizing power supply, having a disconnect position interrupting communication therebetween, a first position establishing communication therebetween energizing the first control valve to the first energized position thereof, and a second position establishing communication therebetween energizing the first control valve to the second energized position thereof;

a second switch interposed between the second control valve and the energizing power supply, having a disconnect position interrupting communication therebetween, a first position establishing communication therebetween energizing the second control valve to the first energized position thereof, and a second position establishing communication therebetween energizing the second control valve to the second energized position thereof; and,

a third switch interposed between the third control valve and the energizing power supply, having a disconnect position interrupting communication therebetween, a first position establishing communication therebetween energizing the third control valve to the first energized position thereof, and a second position establishing communication therebetween energizing the third control valve to the second energized position thereof.

2. The excavator of claim 1 wherein the third switch comprises:

a level sensor supported on the support frame sensing the slope position of the support frame, and having an output signal responsive to the sensed slope position of the support frame;

a command signal source having an output signal responsive to a preset slope position;

a differential amplifier means to receive and compare the output signals from the level sensor and the command signal source, having an output signal responsive to the comparison of the output signals of the level sensor and the command signal source; and,

a signal selector having a portion thereof interposed between the energizing power supply and the third control valve, to receive the output signal from the differential amplifier and to be switchingly positioned in the disconnect position, the first position and the second position, in response to the received output signal of the differential amplifier.

3. The excavator of claim 2 wherein the earth removal means is characterized as including a vertical earth removal assembly comprising:

a forward frame, having an earth engaging face, an upper end, a lower end, a pivot side and a cutting side, the pivot side of the forward frame being pivotally secured to the cutting side of the support frame;

a forward digging implement secured to the cutting side of the forward frame, the forward frame and the forward vertical digging implement connected thereto selectively movable to an earth engaging position and to a storage position, the forward vertical digging implement excavatingly engaging a portion of earth generally along a predetermined vertical plane spaced a distance from the cutting side of the support frame in an earth engaging position thereof and in a forward moving direction of the support frame;

a rearward frame, having an earth engaging face, an upper end, a lower end, a pivot side and a cutting side, the pivot side of the rearward frame being pivotally secured to the cutting side of the support

frame;

a rearward vertical digging implement secured to the cutting side of the rearward frame, the rearward frame and the rearward vertical digging implement connected thereto movable to an earth engaging position and to a storage position, the rearward vertical digging implement excavatingly engaging a portion of earth generally along a predetermined vertical plane spaced a distance from the cutting side of the support frame in an earth engaging position thereof and in a rearward moving direction of the support frame; and,

positioning means for positioning the forward frame and the forward vertical digging implement in an earth engaging position and a storage position, and for positioning the rearward frame and the rearward vertical digging implement in an earth engaging position and a storage position.

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