April 17, 1951 E. D. EKENSTAM 2,549,183

DITCH DIGGING MACHINE

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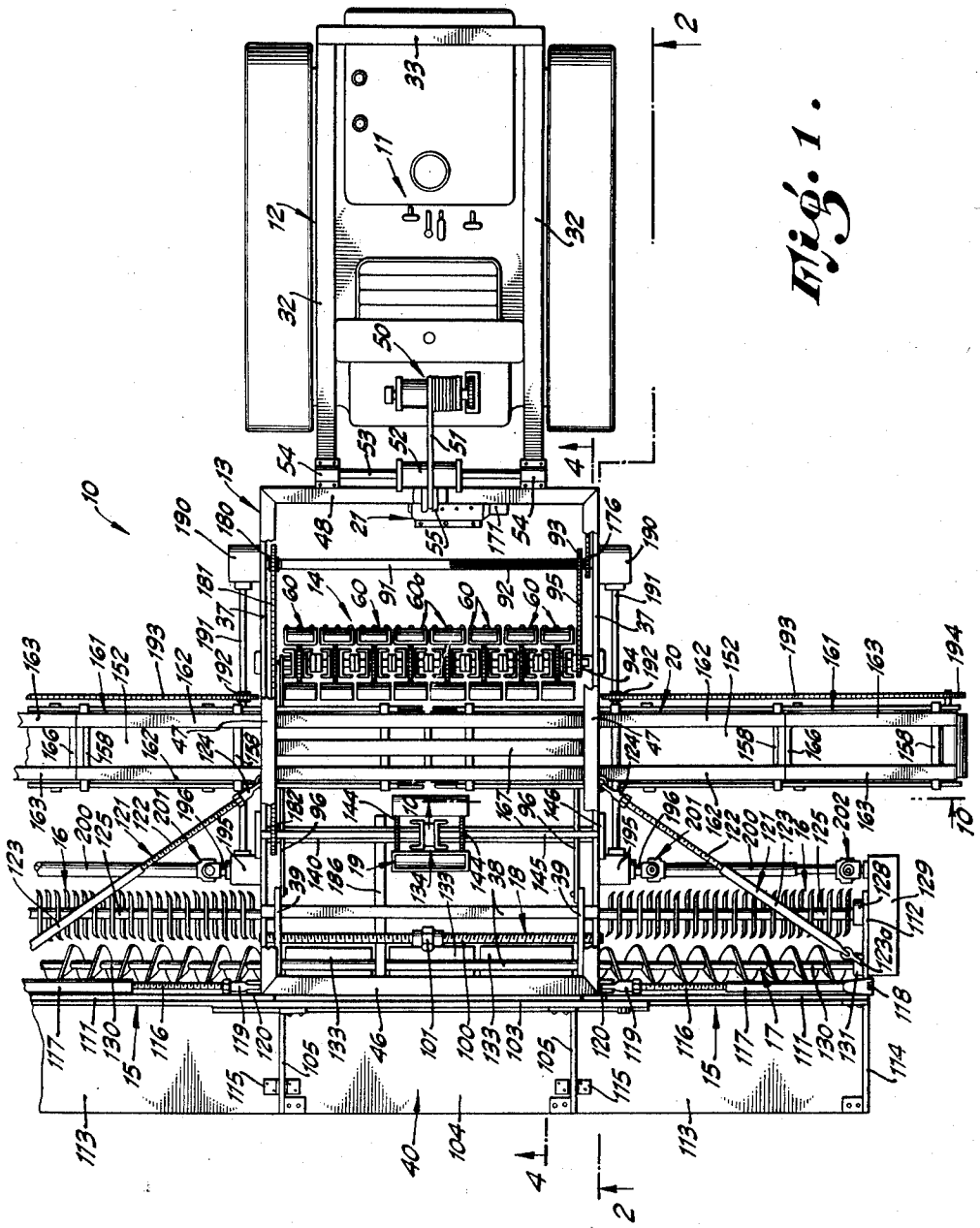


Fig. 1.

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DITCH DIGGING MACHINE

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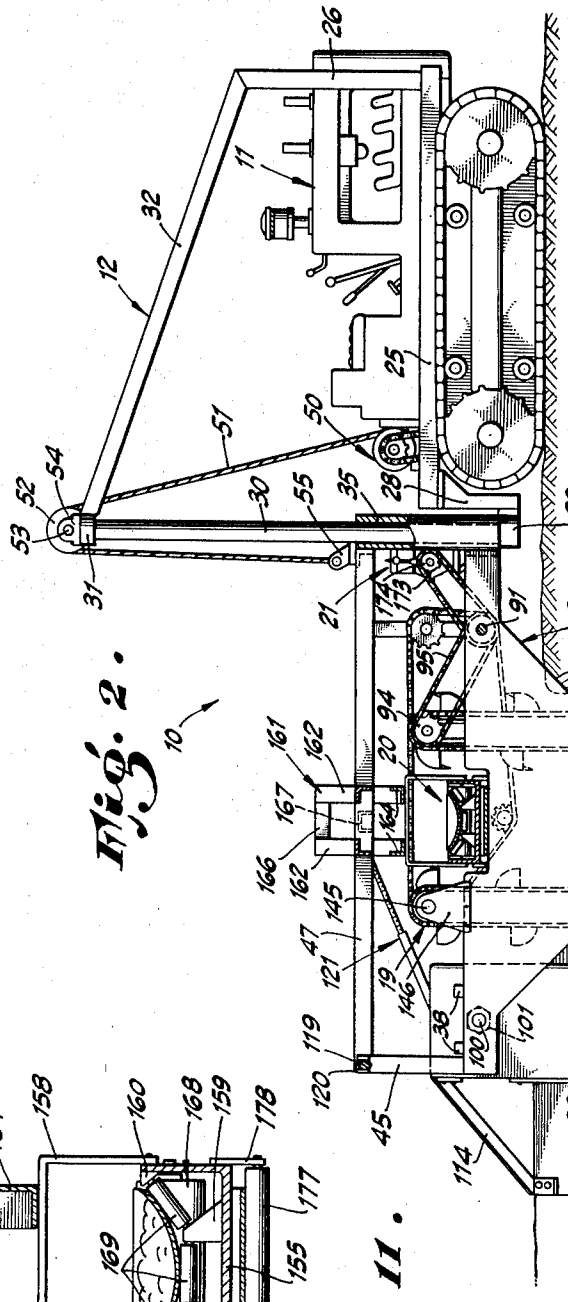


Fig. 2.

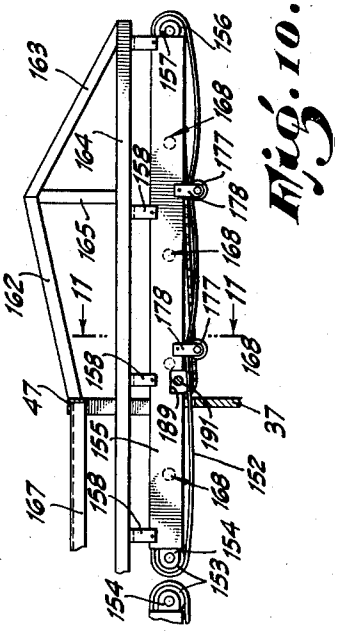


Fig. 10.

Fig. 11.

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DITCH DIGGING MACHINE

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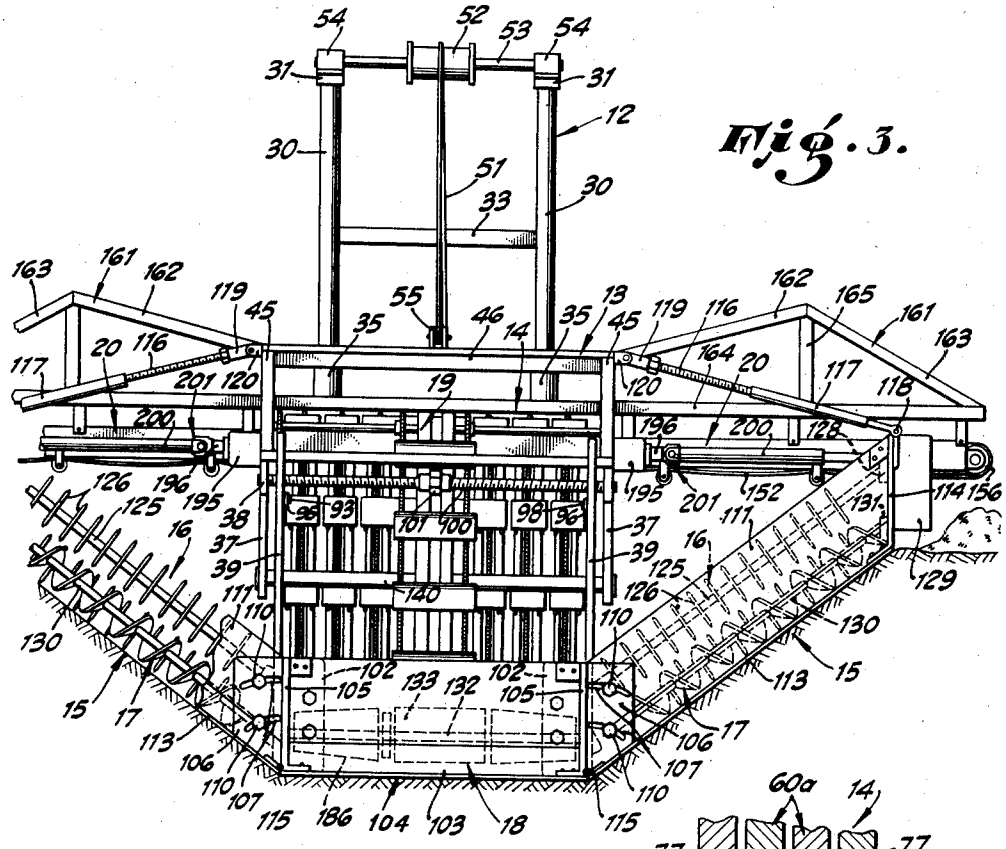


Fig. 3.

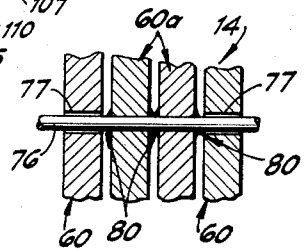


Fig. 9.

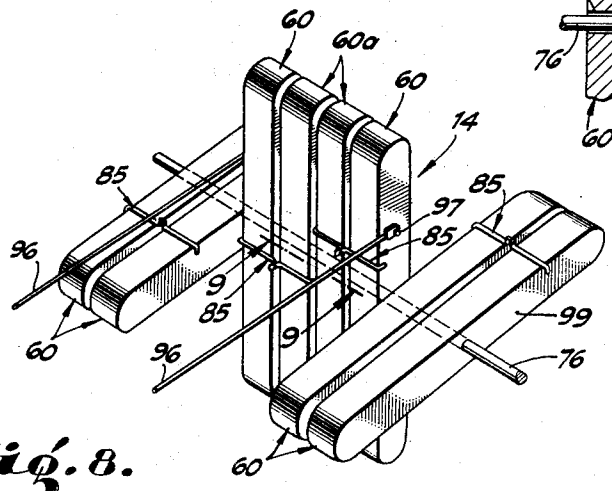


Fig. 8.

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DITCH DIGGING MACHINE

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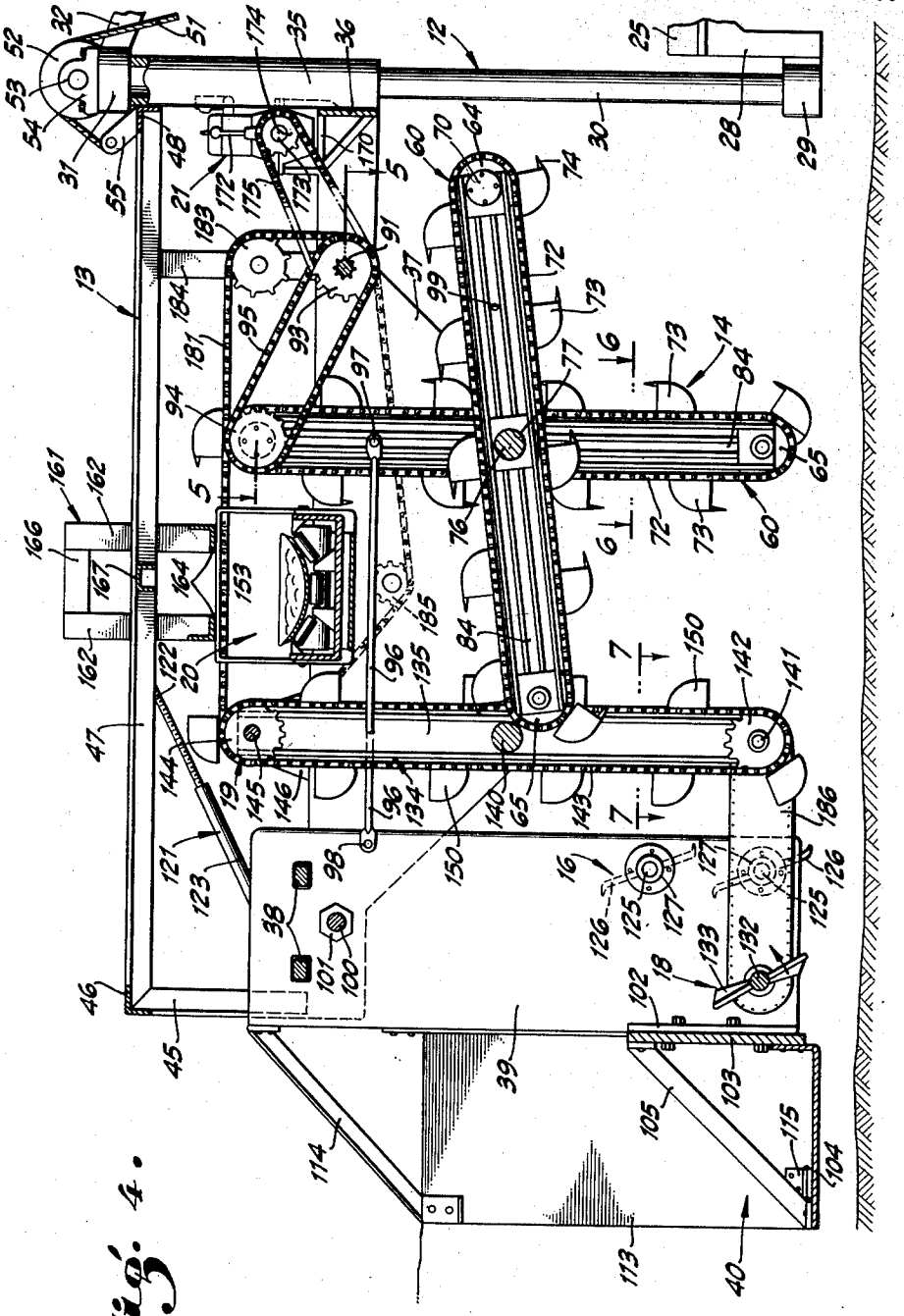


Fig. 4.

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DITCH DIGGING MACHINE

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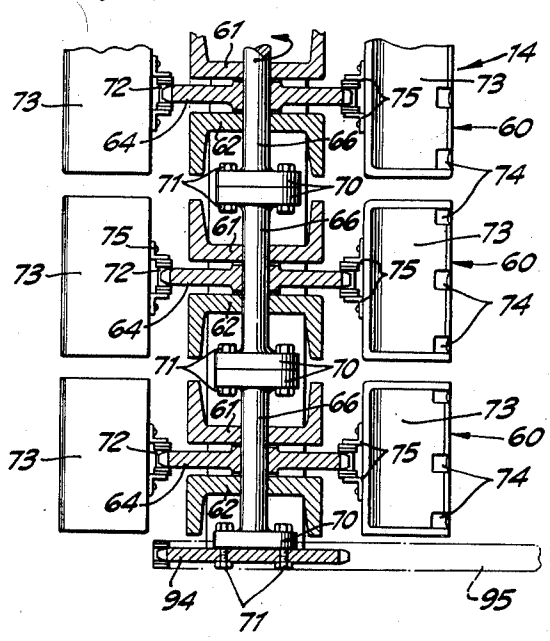
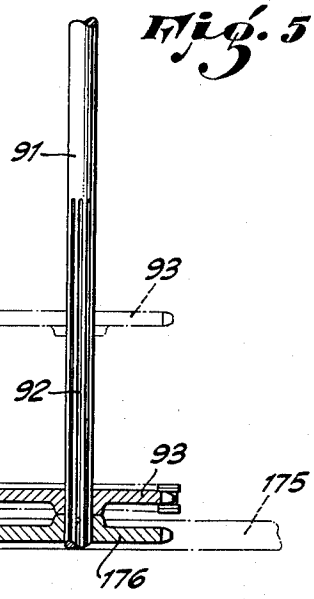


Fig. 5.



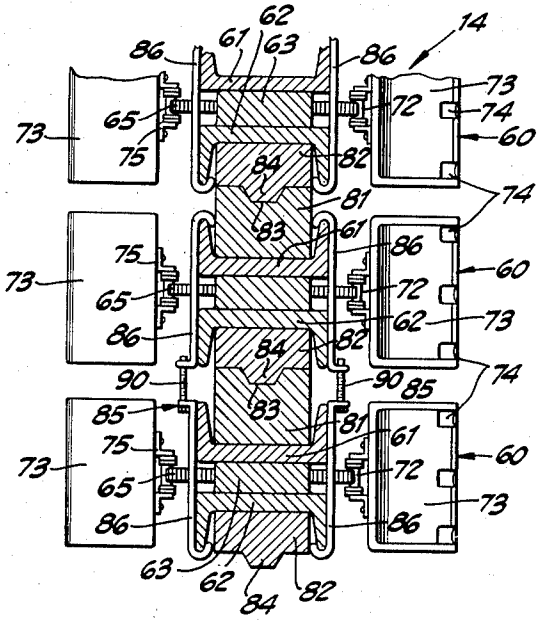


Fig. 6.

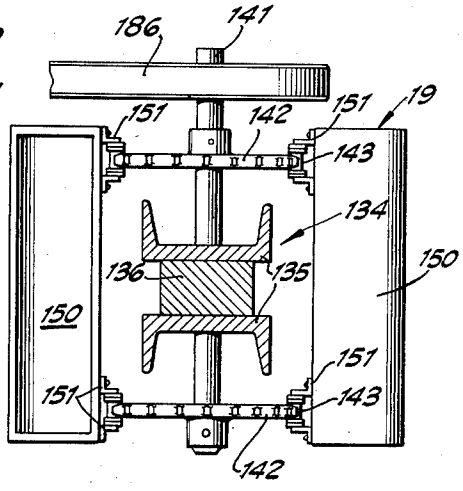


Fig. 7.

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2,549,183

UNITED STATES PATENT OFFICE

2,549,183

DITCH DIGGING MACHINE

Edward D. Ekenstam, Los Angeles, Calif.

Application May 23, 1947, Serial No. 750,121

11 Claims. (Cl. 37—90)

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The present invention relates generally to excavating machines, and is more particularly concerned with a machine for digging drainage or irrigation ditches of the type having a flat bottom and sloping side walls. Such ditches are subsequently paved with a layer of asphalt or other paving material to make them resistant to erosion and to prevent seepage of water in sandy ground, and are extensibly used in the Western States because of their durability, the speed and ease with which they can be constructed, and their low cost of construction.

Heretofore, these ditches have been dug to the required grade by means of power shovels, draglines, scrapers, and the like, and in accordance with time-honored construction practice, have been progressively worked down to grade by repeated passes of the several machines involved. The chief drawback to this arrangement is that the cross-section of the ditch inevitably varies somewhat along its length, due to the fact that even the most skilled operators are unable to control their machines without a certain amount of unavoidable wandering. The resulting irregularities in the sub-grade of the ditch are responsible for a considerable increase in the cost of the subsequent paving operation, particularly when the latter is performed by a one-pass asphalt ditch paving machine of the type shown and described in my co-pending application, Serial No. 573 652, filed January 20, 1945, now Patent No. 2,447,571 issued on August 24, 1948, which produces a finished surface of absolutely uniform contour.

One of the primary objects of the present invention, therefore, is to provide a machine for digging a flat-bottomed, sloping-walled ditch of absolutely uniform contour throughout its entire length, so that the asphalt mat subsequently laid down by a following paving machine will be uniform in thickness and density.

Another important object of the invention is to provide a self-contained, fully automatic machine which does the complete ditch digging job in one operation as the machine advances over the ground, producing a finished sub-grade ready for immediate paving without further processing.

A further object of the invention is to provide a machine which can be adjusted to dig a ditch of any desired depth, width, and wall slope within the range of the machine's capabilities.

Still another object of the invention is to provide a ditch digging machine which is adapted to be mounted on a tractor, and which can be elevated to clear the ground for transport to and from the job.

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The foregoing and other objects and advantages of the invention will become apparent to those skilled in the art upon consideration of the following detailed description of the preferred embodiment thereof, reference being had to the accompanying drawings, in which:

Figure 1 is a top plan view of a tractor mounted ditch digging machine constructed in accordance with the principles of the invention;

Figure 2 is a partially sectioned side elevational view of the same, with the section taken along the line 2—2 in Figure 1;

Figure 3 is a rear end view of the machine;

Figure 4 is an enlarged sectional view taken along the section line 4—4 in Figure 1, but showing the machine raised up to transport position, and also showing the manner in which the outer bucket lines can be swung up to an inoperative, substantially horizontal position in order to reduce the width of the trench being dug;

Figure 5 is an enlarged sectional view taken along the line 5—5 in Figure 4;

Figure 6 is an enlarged sectional view taken along the line 6—6 in Figure 4;

Figure 7 is an enlarged sectional view taken along the line 7—7 in Figure 4;

Figure 8 is a schematic perspective view of the digging bucket lines, illustrating the manner in which any selected number of the bucket lines can be clamped together to form an operatively positioned central group, while the outer lines at each end can be clamped together and turned to inoperative position;

Figure 9 is a schematic drawing, representing a section taken at 9—9 in Figure 8, illustrating the manner in which the two center bucket line supporting structures are fixedly mounted on the transverse shaft, while the outer bucket line structures are pivoted on the shaft so that they can be swung up to inoperative position;

Figure 10 is a sectional view, taken along the line 10—10 in Figure 1, showing one of the transverse conveyors in elevation; and

Figure 11 is an enlarged sectional view, taken along the line 11—11 in Figure 10.

In the drawings, the ditch digging machine of the invention is designated in its entirely by the reference numeral 10 and comprises a structure which is mounted on and supported by suitable propelling means such as the crawler-type tractor illustrated at 11. Mounted on tractor is a supporting structure 12 which carries the main frame 13 of the machine. The frame 13 is movable

vertically with respect to the supporting structure 12, and mounted on said frame transverse to the direction of forward travel is an excavating unit 14 which operates to dig a flat-bottomed trench in the ground as the machine advances. The excavating mechanism 14 is adjustable in its effective width, as will be described in more detail hereinafter, and the trench dug thereby represents the center, flat-bottomed portion of the ditch. Mounted on the rear end of the frame 13 and extending laterally outwardly and upwardly at an angle from the bottom edges of the trench dug by the excavating unit 14 are side sections 15, each of which comprises earth working means 16 in the form of two vertically spaced scarifiers which loosen and break up the earth on either side of the trench to a sloping grade as the machine advances. Following closely behind the bottom scarifier and parallel thereto is a worm conveyor 17 which moves the loosened earth in toward the center of the trench. A rotary beater 18, extending transversely across the bottom of the trench, propels the loosened earth forwardly into the buckets of an elevating conveyor 19. The earth is carried upwardly by the conveyor 19 and dumped onto a transversely extending conveyor 20 comprising two oppositely traveling conveyor belts disposed end-to-end between the elevating conveyor and the excavating unit 14. Material discharged by the excavating unit 14 and elevating conveyor 19 onto the conveyor 20 is carried by the latter out to the edges of the ditch, where it is deposited on the ground. A gasoline engine 21 mounted on the front end of the frame 13 provides power for driving the excavating unit 14, scarifiers 16, worm conveyors 17, rotary beater 18, elevating conveyor 19, and transverse belt conveyors 20, and is operatively connected to each of them by power transmission means which will be described in detail presently.

The supporting structure 12 comprises a pair of laterally spaced, fore and aft extending beams 25 which are disposed on opposite sides of the tractor body and are rigidly secured thereto in any suitable manner. Fixed to and extending upwardly from the front ends of the beams 25 are posts 26, and at the rear end of each of the beams is a downwardly extending arm 28. Welded to the bottom ends of the arms 28 and projecting rearwardly therefrom are base members 29 which support the bottom ends of two vertically disposed, tubular posts 30. The posts 30 are surmounted by cap members 31 which are connected to the top ends of the front posts 26 by downwardly and forwardly extending frame members 32. The frame members 32 and posts 26 are braced laterally at their junctions by means of a transverse frame member 33.

The main frame 13, as mentioned earlier, is mounted on the supporting structure 12 for relative vertical movement, and to this end is provided with a pair of tubular members 35 which are slidable on the vertical posts 30. A vertically disposed, transverse plate member 36 is welded to the lower ends of the slide members 35 on the back sides thereof, and projects laterally beyond the members for a short distance. Welded to the ends of the plate member 36 are two rearwardly extending side frame members 37 which may be made up of any number of suitable structural members joined together to provide a structure of the requisite strength and having the necessary points of attachment for the several operating units mounted thereon, or which may be formed of heavy steel plate, as illustrated in the drawings, cut to the contour shown.

The side frame members 37 are connected together near their rear ends by a pair of fore and aft spaced, transversely disposed beams 38 which carry two laterally spaced, vertical supporting members 39. The supporting members 39 are shiftable laterally on the beams 38, and carry the side sections 15, center rear section 40, and rotary beater 18. Fixed to the extreme rear ends of side frame members 37 and extending upwardly therefrom are angle iron posts 45, the top ends of which are cross-connected by a transverse angle iron 46. Also attached to the top ends of the posts 45 are forwardly extending, horizontal angle irons 47, and these are connected at their front ends by a transverse angle iron 48 which is welded to the back sides of the two tubular slides 35.

The main frame 13 is adapted to be raised and lowered on the tubular posts 30 by means of a winch 50 mounted on the rear end of the tractor. The winch 50 is driven from the tractor engine by any well-known means, and trained around the winch drum is a cable 51 which extends upwardly therefrom and over a drum 52 mounted on a transverse shaft 53 which is journalled at its ends in pillow blocks 54 mounted on top of the cap members 31. After passing over the drum 52, the cable 51 extends downwardly and is attached at its end to a bracket 55 fixed to the transverse angle iron 48 at the approximate mid-point of the latter. The frame 13 is thus raised or lowered to the desired level by merely operating the winch 50 in the appropriate direction, winding up or paying out cable to raise or lower the frame on the posts 30.

The excavating mechanism 14 comprises a plurality of laterally spaced, vertically disposed digging units which, in the preferred form illustrated, consist of eight bucket lines 60 arranged side-by-side, transverse to the direction of forward travel. Each of the bucket lines 60, when in its operative, vertical position, cuts a vertical channel one foot wide through the ground as the machine advances. When all of the bucket lines are vertical, the excavating unit 14 cuts an eight foot, flat-bottomed trench to the maximum depth of six feet. However, when a trench of less than eight foot width is desired, certain of the outer units can be swung around to an inoperative, substantially horizontal position clear of the ground, in which case the trench will be only as wide as the center group of operatively positioned bucket lines.

Each of the bucket lines 60 comprises a rigid frame made up of two laterally spaced channel irons 61 and 62 arranged back-to-back and having spacer blocks 63 disposed between them. The channel irons 61, and 62 are welded or otherwise joined to the spacer blocks 63, which terminate somewhat short of the ends of the channel irons, leaving gaps to receive upper and lower sprockets 64 and 65. The lower sprockets 65 are supported for rotation in any suitable manner on the bottom ends of the channel irons 61, 62; and upper sprockets 64 are mounted on short, transverse shafts 66 which extend through and are journalled in the top ends of the channel irons. Each of the shafts 66 has radial flanges 70 fixed to opposite ends thereof, and these flanges are drilled at circumferentially spaced intervals to receive connecting bolts 71, whereby all of the shafts 66 of the operatively positioned bucket lines can be

connected together to rotate as one. An endless chain 72 is trained over the sprockets 64, 65, and extends up and down along the front and back edges of the channel iron frame members 61, 62. Mounted on each of the chains 72 at spaced intervals along the length thereof are digging buckets 73 having teeth 74 along their outer edges. The buckets 73 are connected to the chain 72 by means of angle brackets 75, and are positioned so that the buckets on the upwardly traveling run of chain on the leading edge of the channel members face upwardly.

The bucket lines 60 are all supported on a transverse shaft 76 which is rigidly attached at its ends to the side frame members 37 and extends through bearing holes 77 provided in the frame structures of the bucket lines at their mid-points. The two center bucket lines 60*a* are permanently fixed in vertical, operative position, and to this end, their respective frame structures are shown in the schematic drawing of Figure 9 as being welded at 80 to the shaft 76. The other bucket lines 60 are all pivoted on the shaft 76 and are swingable down to a substantially horizontal inoperative position, as illustrated in Figures 4 and 8.

Since it is necessary that all of the operatively positioned bucket lines be rigidly locked in place while the machine is functioning, I have provided means for locking the pivoted units to the two rigid center units in any selected combination so as to obtain a ditch of any desired width from two to eight feet, in increments of one foot. The locking means, illustrated in Figure 6, comprises companionate members 81 and 82 which are fixed to channel irons 61 and 62, respectively, on opposite sides of the bucket line frame structures. Each of the members 81 is provided with a longitudinally extending groove 83 which receives a tongue 84 projecting from the adjacent member 82. Clamps 85 are used to clamp the bucket lines together in pairs with their tongue and groove members interlocked, and as shown in Figure 6, these clamps may take the form of pairs of oppositely extending rods 86, the outer ends of which are hooked so as to engage over the edges of the channel member 61, 62. At their adjacent ends, the rods 86 are bent to form right-angle flanges which are connected and drawn together by clamping bolts 90.

The schematic drawing of Figure 8 illustrates the machine set-up for digging a ditch of four foot width. In this case, the two pivoted bucket lines 60 directly adjacent the two rigid center bucket lines 60*a* are clamped together in pairs, so that all four of the center, operatively positioned bucket lines are locked in place. The two pairs of bucket lines on either side of the center group have been clamped together and swung down to inoperative position. To add another unit to the center group, it is necessary only to remove the clamp 85 from one of the outer, inoperative pairs, swing the inner bucket line of the said pair up to operative position, and then clamp it to the adjacent end unit of the center group. It will be understood, of course, that in connecting another unit into the center, operatively positioned group, it is necessary also to connect the sprocket shaft 66 of the new unit onto the end of the adjacent sprocket shaft, so that the newly added bucket line will be driven thereby.

The bucket lines of the operatively positioned group are driven from a drive shaft 91 extending transversely across the frame 13 ahead of the excavating unit 14. The ends of the shaft 91 are

journalled in the side frame members 37, and the right-hand end portion of the shaft is splined at 92 so that a driving sprocket wheel 93 mounted thereon can be shifted laterally to place it in alignment with the end of the sprocket shaft 66 of the outer bucket line in the operative group. A driven sprocket 94 having bolt holes matching the holes in the flanges 70 is mounted directly on the outer end flange, using the bolts 71. A chain 95 trained over sprockets 93, 94, transmits the drive from shaft 91 to the connected sprocket shafts 66 of the operatively positioned group of bucket lines 60.

When the machine is in operation, only the lower portions of the bucket lines 60 in the operatively positioned group engage the ground, as shown in Figure 2, and this imposes a torsional stress of considerable magnitude on the excavating units which are supported at their midpoints on the shaft 76, tending to shear the rigidly fixed center bucket lines 60*a* loose from the shaft 76, or twist the latter. To overcome this unbalanced load condition, I provide a pair of tension rods 96 on either side of the operatively positioned group of bucket lines, which are connected at their front ends by bolts 97 to the supporting frame structures of the outer bucket lines, and at their rear ends, by bolts 98 to the supporting members 39 adjacent the front edges thereof. The bolt 97 of the right-hand rod 96 is screwed into a tapped hole 99 provided in the tongue 84 of each of the members 82 midway between the supporting shaft 76 and the top end of the frame structure; while the left-hand rod 96 is connected at its front end to the member 81 by a suitable bracket (not shown).

The supporting members 39 are always adjusted (by means which will be described presently) to positions in line with the outside edges of the outer bucket lines of the operatively positioned group, and the tension rods 96 are therefore located so that their front ends can be bolted to the outer bucket lines of the operative group, regardless of the width of the latter. As the machine advances over the ground, the rearward thrust of the earth against the lower ends of the bucket lines tends to rotate the bucket lines in a clockwise direction about the shaft 76. This tendency is opposed, however, by the tension rods 96 which are connected to the outer bucket lines of the excavating unit above the shaft 76, and which exert a rearwardly directed force on the bucket lines, restraining them against such clockwise rotational movement.

The side sections 15 which cut the sloping sides of the ditch after the excavating unit 14 has dug out the flat-bottomed trench, are shiftable laterally so that the bottom edges of the sloping side walls coincide with the side edges of the flat-bottomed trench, whatever the width of the latter. To this end, the supporting members 39, carrying the side sections 15, are slidably mounted on the transverse beams 38, and are moved in toward one another or spread apart by means of a turnbuckle 100, the ends of which are journalled in the frame side members 37 and held thereby against axial movement. The two halves of the turnbuckle 100 are threaded in opposite directions, and these threaded portions pass through tapped holes in the supporting members 39 and have a screw engagement therewith. A hexagonal wrench head 101 at the midpoint of the turnbuckle, enables the operator to turn the latter for the purpose of adjusting the distance between supporting members.

Extending transversely across the bottom of the ditch and bolted to flanges 102 extending laterally inward from the lower rear edges of the supporting members 39 is a vertical plate member 103 which functions as a mold board to accumulate and push along the loosened earth brought down into the bottom of the ditch by the worm conveyors 17, so that the rotary beater 18 is enabled to kick the earth forwardly into the elevating conveyor 19. A rearwardly extending pan 104 is attached to the back side of the plate 103 along the bottom edge thereof, and its purpose is to bear on the ground so as to stabilize the machine and hold it to grade, and also to smooth the surface of the ditch. The pan 104 is braced at each end by a strut 105 which extends downwardly and rearwardly from the top edge of the plate 103 to the rear edge of the pan. Both plate 103 and pan 104 are replaced by others of different length whenever the supporting members 39 are adjusted in or out.

The ends of the plate 103 project laterally beyond the supporting members 39 to form extensions 106, and these extensions are mitered at their bottom corners to the angle of the maximum wall slope at which the machine can be set, which, in the case of the machine illustrated, is approximately 45° for a one-to-one slope. Formed in each of the lateral extensions 106 of the plate 103 are two vertically spaced, arcuate slots 107 having their centers at the junction of the miter with the flat-bottomed edge of the plate 103. Bolts 110 are passed through these slots and through holes in the lower ends of side section plate 111 so that the latter can be bolted to the ends of the plate 103 to form upwardly and outwardly directed side continuations thereof. The slots 107 permit the side sections to be raised or lowered to any desired angle by merely loosening the bolt 110.

The upper end of each of the plates 111 is cut off perpendicular to the ground, and fixed to this vertical edge is a forwardly extending end plate 112. A rearwardly extending pan 113 is secured to the back side of the plate 111 along the bottom edge thereof and is braced at its upper end to the top edge of the plate by a strut 114. The lower end of the pan 113 is joined to the end of the center pan 104 by a hinge 115 adjacent the bottom end of the strut 105, and is braced by the latter. The hinge 115 provides a flexible connection between the center pan 104 and side pan 113, permitting the latter to be adjusted angularly with respect to the former.

The side sections 15 are adjustable angularly with respect to the flat bottom of the ditch to vary the slope of the side walls within the approximate range of 1:1 to 3:1, and this is accomplished by means of a screw jack comprising a threaded rod 116 which is screwed into a threaded tube 117. The outer end of the tube 117 is pivotally connected to a bracket 118 on the end plate 112, while the inner end of the rod 116 is swiveled on a yoke 119 which is pivotally connected to a bracket 120 fixed to the frame 13 at the corner junction at the angle irons 45, 46 and 47. The slope of the ditch side walls is increased by screwing the jack shaft 116 down into the tube 117, thereby shortening the effective length of the two members; or decreased by backing the jack shaft out of the tube 117 to increase their effective length.

The outer ends of the side sections 15 are connected to the main frame 13 by forwardly and inwardly extending drag links 121 which brace the side sections against rearward deflection caused by the pressure of the earth against the scarifiers 16 as the machine is pulled forwardly. The drag links 121 must be adjustable in length to accommodate angular adjustments of the side sections 15, as well as lateral adjustments thereof for width, and to this end, each of the drag links comprises a threaded rod 122 which is screwed into a threaded tube 123. The front end of the rod 122 is swiveled on a yoke 124 which is flexibly connected to the angle iron 47; while the outer or rear end of the tube 123 is flexibly connected to a bracket 123a which is fixed to the top edge of the end plate 112 just ahead of the bracket 118. Each of the drag links 121 is adjusted in length simultaneously with the screw jack 116, 117 whenever the side sections 15 are shifted laterally or adjusted angularly.

The two scarifiers 16 and worm conveyor 17 of each side section are supported at their outer ends on the end plate 112, and at their inner ends on the supporting member 39. The scarifiers 16 each comprise a shaft 125 having a plurality of axially spaced, radially extending teeth 126 fixedly mounted thereon; the teeth of the upper scarifier being staggered with respect to those of the lower one. Each of the shafts 125 is journalled at its lower or inner end in a self-aligning bearing 127 (Figure 4) mounted on the supporting member 39. The outer ends of the shafts 125 extend through bearings 128 into a gear box 129 mounted on the outside of the end plate 112, and are operatively connected to power transmission mechanism in the box to be driven thereby. The worm conveyor 17 likewise comprises a shaft 130 which is journalled at its inner end in a self-aligning bearing, and the outer end of which extends through a bearing 131 on the end plate 112 into the gear box 129, where it is connected to the driving mechanism.

The angularly disposed scarifiers 16 rotate at fairly high speed, and the teeth 126 thereof chop into the earth on either side of the trench, cutting the soil loose and breaking it up. The loosened earth is carried by the worm conveyor 17 down the slope and in toward the center of the trench where it is scooped up and pushed forwardly by the center plate 103, at the same time being propelled forwardly by the rotary beater 18. The rotary beater 18 comprises a transverse shaft 132 extending across the bottom of the trench in lateral alignment with the two worm conveyors 17, and having its ends journalled in suitable bearings on the supporting members 39. Fixedly mounted on the shaft 132 are spirally twisted paddles 133 which kick the loosened earth forwardly and in toward the center of the trench where it is picked up by the buckets of the elevating conveyor 19.

The elevating conveyor 19 comprises a rigid frame structure 134 made up of two channel irons 135 (Figure 7) which are arranged back-to-back and separated by a spacer block 136, to which the channels are welded or otherwise suitably joined. The structure 134 is rigidly mounted at its midpoint on a transverse shaft 140 which is supported at its ends on the frame side members 37. Journalled in the bottom ends of the structure 134 and projecting laterally from both sides thereof is a shaft 141 having two sprockets 142 fixedly mounted thereon on opposite sides of the structure. Endless chains 143 are trained around the sprockets 142 and carried up the front and back sides of the structure 134. At the top end of the structure, the chains 143 pass over

sprockets 144 which are mounted on a transverse shaft 145 extending across the entire width of the frame 13. The ends of the shaft 145 are journalled in bearings mounted in brackets 146 which are fixed to the top edges of the frame members 37 and extend upwardly therefrom. A plurality of conveyor buckets 150 are attached to the chains 143 at spaced intervals along the length thereof by brackets 151, and are disposed so that the upwardly traveling buckets along the back side of the structure 134 are positioned right side up.

As mentioned earlier, the elevating conveyor 19 and excavating mechanism 14 discharge the earth carried by their respective buckets onto the transverse conveyor 20 as the said buckets pass over the top sprockets. The transverse conveyor 20 is located between the elevating conveyor 19 and excavating mechanism 14 adjacent their upper ends, and comprises two oppositely traveling conveyor belts 152 which are arranged end-to-end, with their adjacent ends spaced as closely together as possible. At their inner ends, the belts 152 are trained around rollers 153, each of which is rotatably supported between the ends of two fore and aft spaced brackets 154 projecting laterally inward from the inner ends of transverse channel frame members 155. The outer ends of the conveyor belts 152 are trained around driving pulleys 156, each of which is likewise rotatably supported between the ends of two brackets 157 projecting laterally outward from the outer ends of the channel members 155.

Each of the channel members 155 is disposed with its horizontal bottom panel extending between the top and bottom runs of the belt 152, and with its side panels extending upwardly along the front and rear edges of the top run of the belt. The channel members 155 are supported by a plurality of laterally spaced inverted V-shaped hangers 158 which are fixed to and depend from a pair of fore and aft spaced, transversely extending angle irons 164. The angle irons 164 are supported, in turn, by a pair of A-frames 161 extending laterally outward from opposite sides of the frame 13. Each of the A-frames 161 is made up of two fore and aft spaced, parallel angle irons 162 which are welded at their inner ends to the outside surface of the frame members 47, and extend laterally outward and upward therefrom. Welded to the outer ends of the angle irons 162 are downwardly and outwardly extending members 163 which are joined at their outer ends to the outer ends of the angle irons 164. Vertical posts 165 extend downwardly from the junction of members 162 and 163, and are attached at their bottom ends to the transverse angle irons 164. The junction of members 162, 163 and 164 is additionally braced by a fore and aft extending cross bar 166. The two frame members 47 of the main frame 13 are braced to take the loads of the A-frames 161 by means of an inverted channel member 167 which extends between and is welded to the members 47 midway between the members 162.

Supporting the top run of the conveyor belt 152 at spaced intervals along the length thereof are roller assemblies 168, each comprising three rollers 169 arranged in the angular disposition shown in Figure 11, which causes the conveyor belt to buckle into the form of an upwardly facing trough, so as to confine the dirt carried on the belt and prevent the same from falling off to either side. The rollers 169 are journalled on brackets 159 and 160 which are fixed to the inside surfaces of the channel member 155. The slack bottom run of the belt 152 is carried up over idler rollers 177 which are journalled in brackets 178 extending downwardly from the sides of the channel member.

Power for driving all of the operating units of the machine is derived from the gasoline engine 21, which is supported on the transverse plate member 36 between the tubular slides 35, by an engine mount structure 170. Mounted directly on the end of the engine crank case is a reduction gear box and clutch housing 171, and projecting upwardly from the housing 171 is a clutch release lever 172. A drive shaft 173 extends laterally from the housing 171, and mounted on its outer end is a sprocket 174. Trained around the sprocket 174 is a chain 175 which drives a sprocket 176 mounted on the end of shaft 91 alongside the right hand frame member 37. Another sprocket 180 fixed on the other end of the shaft 91, drives a chain 181 extending rearwardly therefrom to a sprocket 182 fixed on the top shaft 145 of the elevating conveyor 19. In order to clear the conveyor belt 152 and any dirt carried thereon, the top run of chain 181 is carried up over an idler sprocket 183 which is rotatably supported on a vertical frame member 184 extending between the top frame member 47 and lower member 37. The bottom run of the chain 181 is carried under the conveyor belt 152 and is trained around an idler sprocket 185 which is journalled on the left-hand frame member 37 beneath the conveyor belt. The rotary beater 18 is driven from the bottom shaft 141 of the elevating conveyor 19 by means of a sprocket and chain drive which are enclosed within a housing 186 to protect them from the loose dirt in which they would otherwise be buried.

Mounted on the outside of each of the side frame members 37 in line with the transverse drive shaft 91 are two gear boxes 190 containing right angle drive gearing. The two ends of the shaft 91 extend into their respective gear boxes 190 and are operatively connected to the gearing contained therein. A drive shaft 191 projects rearwardly from each of the gear boxes 190, passing between the top and bottom runs of the conveyor belt 152 and extending through a notch 189 provided in the bottom of the channel member 155. A sprocket 192 which is fixed to the drive shaft 191 adjacent the leading edge of the conveyor belt, drives a chain 193 extending laterally outward to a drive sprocket 194 on the outer roller 156.

The rear end of each of the drive shafts 191 extends into a right angle drive gear box 195 mounted on the frame member 37 directly behind the bracket 146, and the laterally extending output shaft 196 of the gear box is connected by a telescopic shaft 200 and universal joints 201 and 202 to the gear box 129 at the outer end of the side section 15. The gearing within the box 129 drives the two scarifiers 16 in a counterclockwise direction at a fairly high speed, and the worm conveyor 18 in the same direction but at a greatly reduced speed.

In starting the excavation of a new ditch, one of the first steps is to remove the pans 104 and 113 so that the machine will be enabled to dig down into the ground to the required depth. The excavating unit 14 is then set up with the appropriate number of bucket lines 60 locked together in operative position so as to dig a flat bottomed trench of the desired width, after which the rear end plate 103 and rotary beater 18 are

removed (if necessary) to enable the supporting members 39 to be shifted laterally by the turnbuckle 100 into alignment with the outer edges of the operatively positioned group of bucket lines. When the members 39 have been satisfactorily adjusted, a plate 103 and beater 18 of corresponding length are mounted in place. The side sections 15 are then shifted to the proper angle by turning screw shafts 116 and 122, to raise or lower the outer ends thereof.

The engine 21 is started, and the clutch lever 172 is shifted to engage the clutch, thereby transmitting driving power to the several operating units of the machine. The frame 13 is then lowered by the winch 50 until the bucket lines 60 engage the ground, and while the tractor is driven slowly forward, the frame 13 is gradually lowered into the ground. The bucket lines 60 cut slightly below the following elevating conveyor 19, rotary belts 18, and plate 103, and in consequence, the machine is able to cut its way down into the ground. When the desired depth has been reached, the winch 50 is stopped and locked, and is thereafter operated only where necessary to increase or decrease the depth of the ditch to maintain a constant guide in the bottom of the ditch. As soon as the machine has reached the proper depth, the pans 104 and 113 are replaced, and the machine is then in readiness for normal operation.

In transporting the machine to and from the job, the frame 13 is raised by the winch 50 to the top of the posts 30, as shown in Figure 4, in which position it clears the ground. It might be mentioned here that while the machine appears in the drawings to overbalance the tractor 11 so that the front end of the latter might be lifted off the ground, this is not the case, as the weight of the tractor frame and engine is so much greater than the weight of the rearwardly overhanging machine that the front end of the tractor is held down on the ground.

While I have shown and described in considerable detail what I believe to be the preferred form of my invention, it is to be understood that this is merely an illustrative embodiment, and that various changes may be made in the shape and arrangement of the several parts without departing from the broad scope of the claims appended hereto.

I claim:

1. A ditch digging machine comprising, in combination, a frame adapted to be propelled along the course of the ditch and adjustable vertically with respect to the ground, excavating means carried by said frame for digging a trench in the ground as the machine advances, said excavating means being adjustable in its effective width to vary the width of the trench dug thereby, earth working means arranged to the rear of said excavating means for loosening and breaking up the earth on either side of said trench to a sloping grade, means for shifting said earth working means laterally to coincide with the sides of said trench, and angularly to vary the slope of the ditch side walls, and means for removing the earth loosened up by said earth working means and conveying the same to the margins of the ditch.

2. A ditch digging machine comprising, in combination, a frame adapted to be propelled along the course of the ditch, excavating means mounted on said frame for digging a trench in the ground as the machine advances, said excavating means being adjustable in its effective width to vary the width of the trench dug thereby, earth working means on said frame to the rear of said excavating means for loosening and breaking up the earth on either side of said trench to a sloping grade, means for shifting said earth working means laterally with respect to said frame to coincide with the side edges of said trench, and means for conveying the loosened earth to the margins of the ditch.

3. A ditch digging machine comprising, in combination, a frame adapted to be propelled along the course of the ditch, excavating means mounted on said frame for digging a trench in the ground as the machine advances, said excavating means comprising a plurality of laterally spaced digging units arranged side-by-side, transverse to the direction of forward travel, certain of said units being movable with respect to said frame to inoperative positions clear of the ground for reducing the width of the trench dug by said excavating means, earth working means on said frame to the rear of said excavating means for loosening and breaking up the earth on either side of said trench to a sloping grade, means for shifting said earth working means laterally with respect to said frame to coincide with the side edges of said trench, and means for conveying the loosened earth to the margins of the ditch.

4. A ditch digging machine comprising, in combination, a frame adapted to be propelled along the course of the ditch, excavating means mounted on said frame for digging a trench in the ground as the machine advances, said excavating means comprising a plurality of laterally spaced bucket lines arranged side-by-side, transverse to the direction of forward travel, each of said bucket lines consisting of a normally vertical frame structure supported intermediate its ends on said frame, a pair of shafts journaled on said structure at opposite ends thereof, a sprocket mounted on each of said shafts, an endless chain trained over said sprockets and extending along the front and back edges of said structure, a plurality of digging buckets mounted on said chain, certain of said bucket lines being swingable about the point of support of their respective frame structures between vertical operative position and substantially horizontal inoperative position clear of the ground, means for locking a selected group of said bucket lines in operative position, means for interconnecting the shafts at the top ends of the bucket lines in said selected operative group, means adapted to be connected to one end of said interconnected shafts for driving the same so that the buckets on the front edges of said structure are caused to bite into the ground as the machine advances, earth working means on said frame to the rear of said excavating means for loosening and breaking up the earth on either side of said trench to a sloping grade, said earth working means being shiftable laterally with respect to said frame to coincide with the side edges of said trench, and means for conveying the loosened earth to the margins of the ditch.

5. A ditch digging machine comprising, in combination, a frame adapted to be propelled along the course of the ditch, excavating means mounted on said frame for digging a trench in the ground as the machine advances, said excavating means comprising a plurality of laterally spaced bucket lines arranged side-by-side, transverse to the direction of forward travel, certain of said bucket lines being swingable about a horizontal axis disposed intermediate the ends of said bucket

lines between vertical operative position and substantially horizontal inoperative position clear of the ground, means for locking a selected group of said bucket lines in operative position, means for driving only the bucket lines in said selected operative group so that the buckets carried thereby are caused to bite into the ground as the machine advances while the bucket lines in said inoperative position remain idle, and transversely arranged conveying means disposed to the rear of said bucket lines adjacent the upper ends thereof to receive the soil discharged by said bucket lines and deposit the same along the margins of the ditch.

6. A ditch digging machine comprising, in combination, a main frame adapted to be propelled along the course of the ditch, excavating means mounted on said frame for digging a trench in the ground as the machine advances, said excavating means being adjustable in its effective width to vary the width of the trench dug thereby, a pair of laterally spaced supporting members mounted on the rear end of said main frame and movable toward and away from one another, means for adjusting the spacing of said supporting members to correspond with the width of said trench, earth working means supported at one end on each of said supporting members and extending upwardly and outwardly from the bottom edges of the trench, said earth working means being operative to loosen and break up the earth on either side of said trench to a sloping grade, and means for conveying the loosened earth to the margins of the ditch.

7. A ditch digging machine comprising, in combination, a main frame adapted to be propelled along the course of the ditch, excavating means mounted on said frame for digging a trench in the ground as the machine advances, said excavating means being adjustable in its effective width to vary the width of the trench dug thereby, a pair of laterally spaced supporting members mounted on the rear end of said main frame and movable toward and away from one another, means for adjusting the spacing of said supporting members to correspond with the width of said trench, earth working means supported at one end on each of said supporting members and extending upwardly and outwardly from the bottom edges of the trench, said earth working means being operative to loosen and break up the earth on either side of said trench to a sloping grade, conveyor means for moving the loosened earth in toward the center of said trench, a rotary beater extending transversely across the bottom of said trench and having its ends journaled in said supporting members, said beater being operative to propel forwardly the loosened earth moved into the bottom of said trench by said conveyor means, elevating means positioned ahead of said beater to receive the earth propelled forwardly thereby, and other conveyor means disposed to receive the earth discharged from said elevating means and to carry the same to the margins of the ditch.

8. A ditch digging machine comprising, in combination, a main frame adapted to be propelled along the course of the ditch, excavating means mounted on said frame for digging a trench in the ground as the machine advances, said excavating means being adjustable in its effective width to vary the width of the trench dug thereby, a pair of laterally spaced supporting members mounted on the rear end of said main frame and movable toward and away from one another, means for adjusting the spacing of said supporting members to correspond with the width of said trench, earth working means supported at one end on each of said supporting members and extending upwardly and outwardly from the bottom edges of the trench, said earth working means being adjustable angularly with respect to the bottom of the ditch and being operative to loosen and break up the earth on either side of said trench to a sloping grade, and means for conveying the loosened earth to the margins of the ditch.

9. A ditch digging machine comprising, in combination, a main frame adapted to be propelled along the course of the ditch, excavating means mounted on said frame for digging a trench in the ground as the machine advances, said excavating means being adjustable in its effective width to vary the width of the trench dug thereby, a pair of laterally spaced supporting members mounted on the rear end of said main frame and movable toward and away from one another, means for adjusting the spacing of said supporting members to correspond with the width of said trench, a pair of vertically spaced rotary scarifiers journaled at one end on each of said supporting members and extending laterally upwardly and outwardly from the bottom edges of the trench, a worm conveyor located behind the bottom scarifier of each side and extending parallel thereto, said worm conveyor being operable to move the earth loosened by said scarifiers in toward the center of said trench, said scarifiers and said worm conveyors being movable angularly with respect to said supporting members to vary the slope of the ditch side walls, journal means supporting the outer ends of said scarifiers and worm conveyors, means adjustably connecting said journal means to said main frame whereby said scarifiers and worm conveyors can be adjusted in angular position, and means for elevating the loosened earth in the bottom of said trench and conveying the same to the sides of the ditch.

10. A ditch digging machine comprising, in combination, a supporting structure adapted to be mounted on a tractor, a frame carried by said supporting structure and movable vertically with respect thereto, means for raising and lowering said frame, excavating means mounted on said frame for digging a trench in the ground as the machine advances, earth working means arranged to the rear of said excavating means for loosening the earth on either side of said trench to a sloping grade, conveyor means for removing the loosened earth to the sides of the ditch, an engine mounted on said frame, and power transmission means for driving said excavating means, earth working means, and conveyor means from said engine.

11. A ditch digging machine comprising, in combination, a tractor, a supporting structure mounted on said tractor and having a pair of vertically disposed posts, a main frame slidably mounted on said posts, means on said tractor for raising and lowering said main frame, excavating means for digging a trench in the ground as the machine advances, said excavating means comprising a plurality of laterally spaced bucket lines arranged side-by-side, transverse to the direction of forward travel, certain of said bucket lines being rigidly secured to said frame in vertical operative position and the balance of said bucket lines being movable between operative position and substantially horizontal inoperative

position, means for locking a selected group of said bucket lines in operative position, means for connecting said group of operatively positioned bucket lines so that they operate as one, a pair of laterally spaced supporting members mounted on the rear end of said main frame and movable toward and away from one another, means for adjusting the spacing of said supporting members to correspond with the width of said trench, a pair of vertically spaced rotary scarifiers journaled at one end in each of said supporting members and extending laterally upwardly and outwardly from the bottom edges of the trench, a worm conveyor located behind the bottom scarifier of each side and extending parallel thereto, said worm conveyor being operable to move the earth loosened by said scarifiers in toward the center of said trench, said scarifiers and said worm conveyors being adjustable angularly with respect to said supporting members, a rotary beater extending transversely across the bottom of said trench and having its ends journaled in said supporting members, said beater being operative to propel forwardly the loosened earth moved into the bottom of said trench by said worm conveyors, an elevating conveyor positioned ahead of said beater to receive the earth propelled thereby, a pair of oppositely traveling, transversely arranged belt conveyors disposed end-to-end between said elevating conveyor and said bucket lines to receive earth discharged by both of them and to carry said earth to the margins of the ditch, an engine mounted on said main frame, and power transmission means for driving said bucket lines, scarifiers, worm conveyors, rotary beater, elevating conveyor, and belt conveyors from said engine.

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