United States Patent

Shelley

[15] **3,646,767**

[45] **Mar. 7, 1972**

[54] DITCH BUILDING APPARATUS

[72] Inventor: **Ned R. Shelley**, 119 W. Jackson, Riverton, Wyo. 82501

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[21] Appl. No.: **820,223**

[52] **U.S. Cl.** **61/41**, 61/63, 61/72.2

[51] **Int. Cl.** **E02f 5/02**

[58] **Field of Search** ..... 61/41, 63, 72.2, 72.5, 72.7; 37/70, 80 A, 81, 91, 94

[56] **References Cited**

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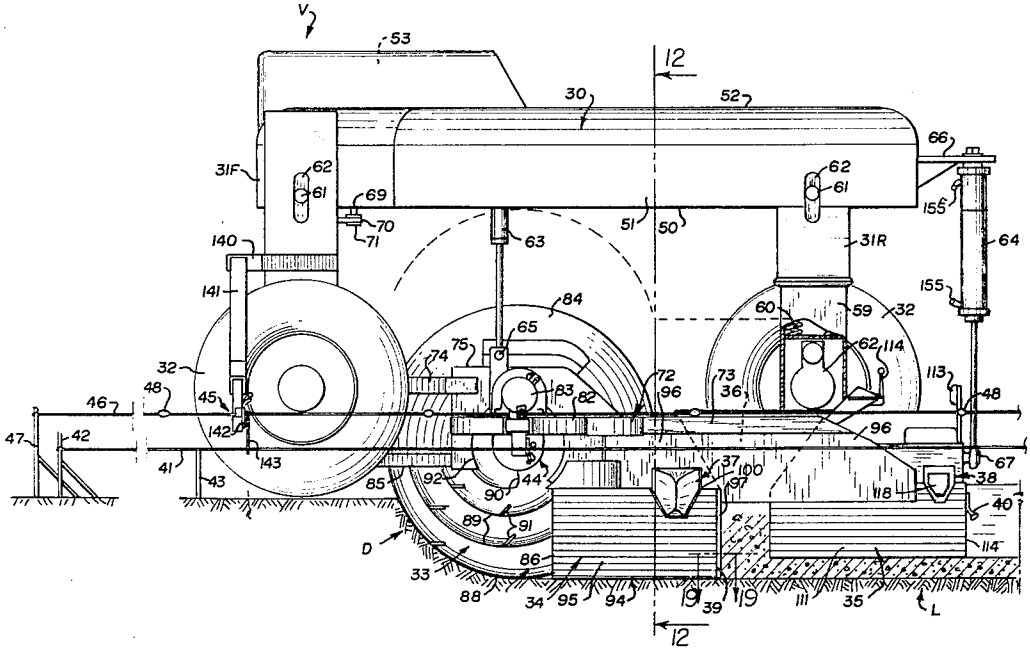
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Primary Examiner—Dennis L. Taylor
Attorney—Lynn G. Foster

[57] **ABSTRACT**

A ditch building apparatus adapted to excavate a ditch trench and to line the same with concrete. The apparatus combines a digger, a concrete hopper and a forming section adapted to finish off the concrete. The apparatus is suspended from a vehicle with adjustable suspension means to hold the same at a proper depth and grade and to hold it level even with the movement of the vehicle over an irregular ground surface. A pocket forming and pocket finishing apparatus is carried on the digger and forming section. The pocket forming apparatus includes a ram which cuts a pocket in the earth at the side of a ditch trench which is then filled with concrete. The notch finishing apparatus includes a ram which extends into the pocket to form a notch in the concrete therein.

15 Claims, 20 Drawing Figures



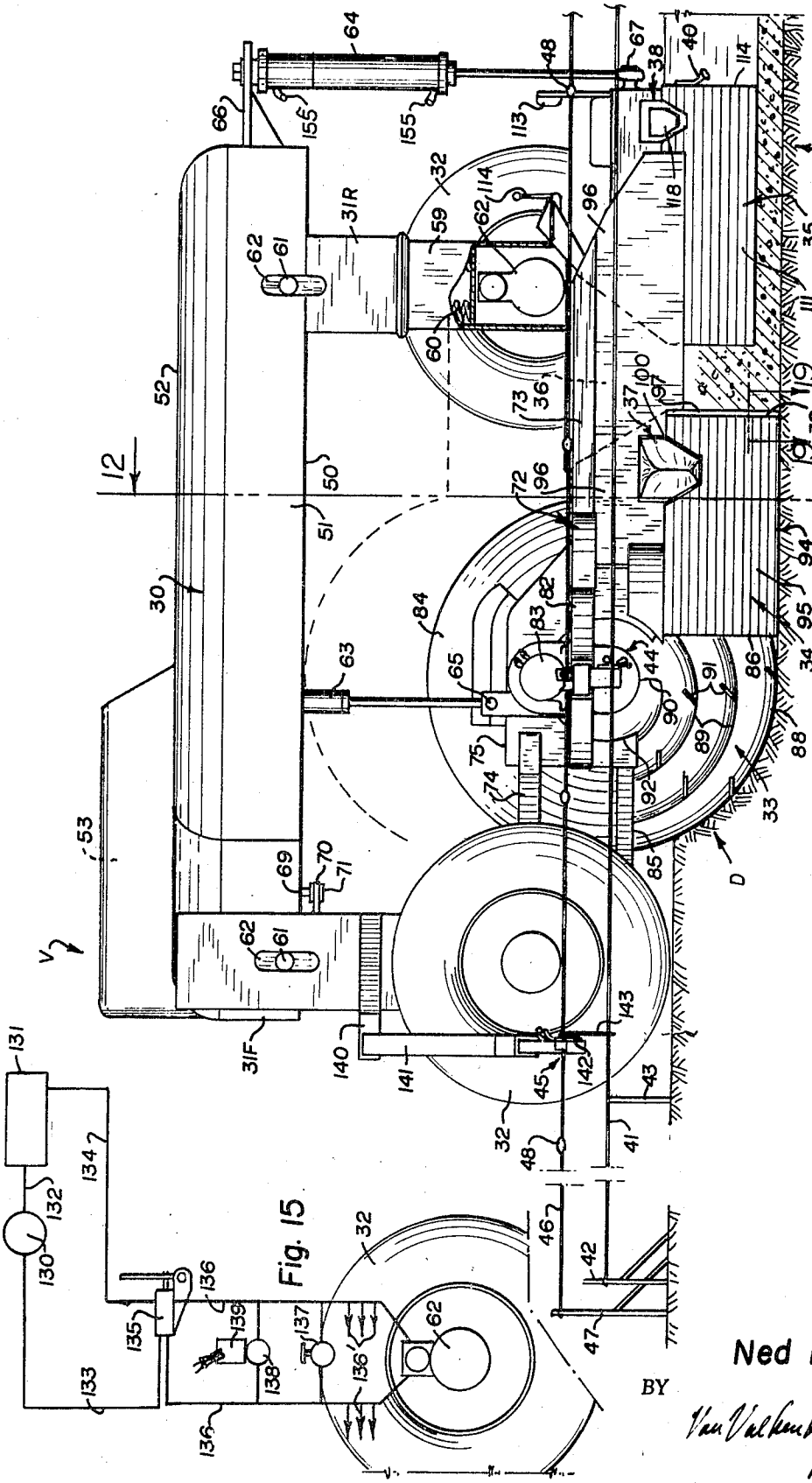


Fig. 1

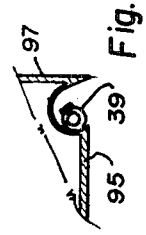


Fig. 19

Fig. 15

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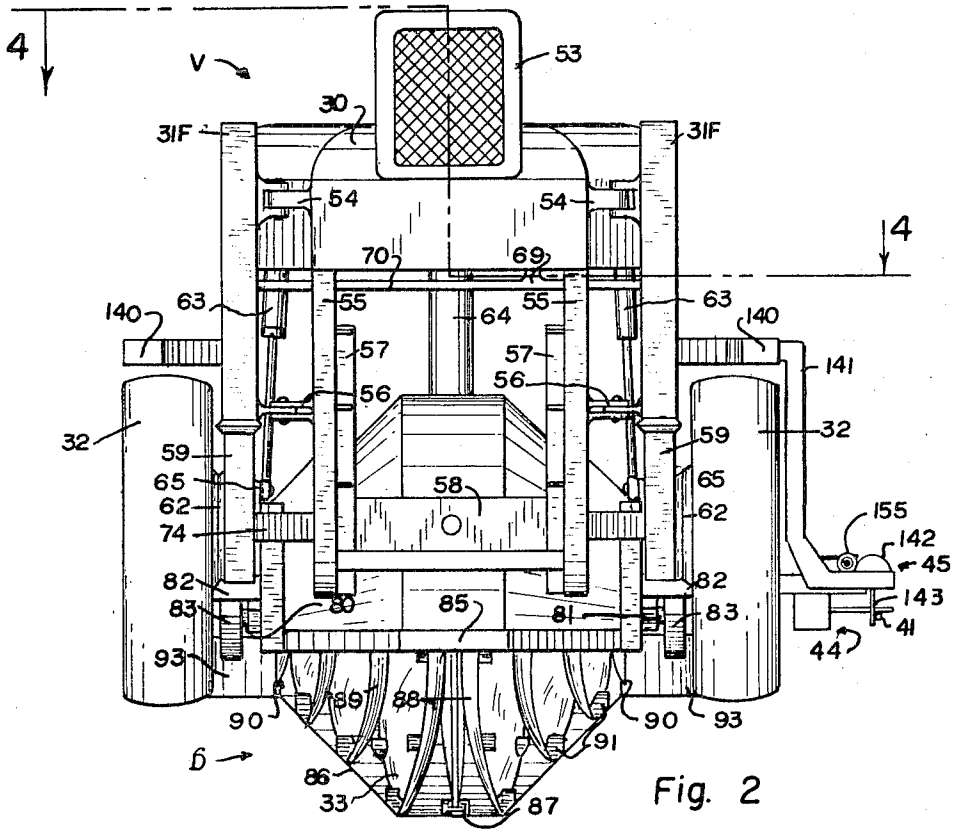


Fig. 2

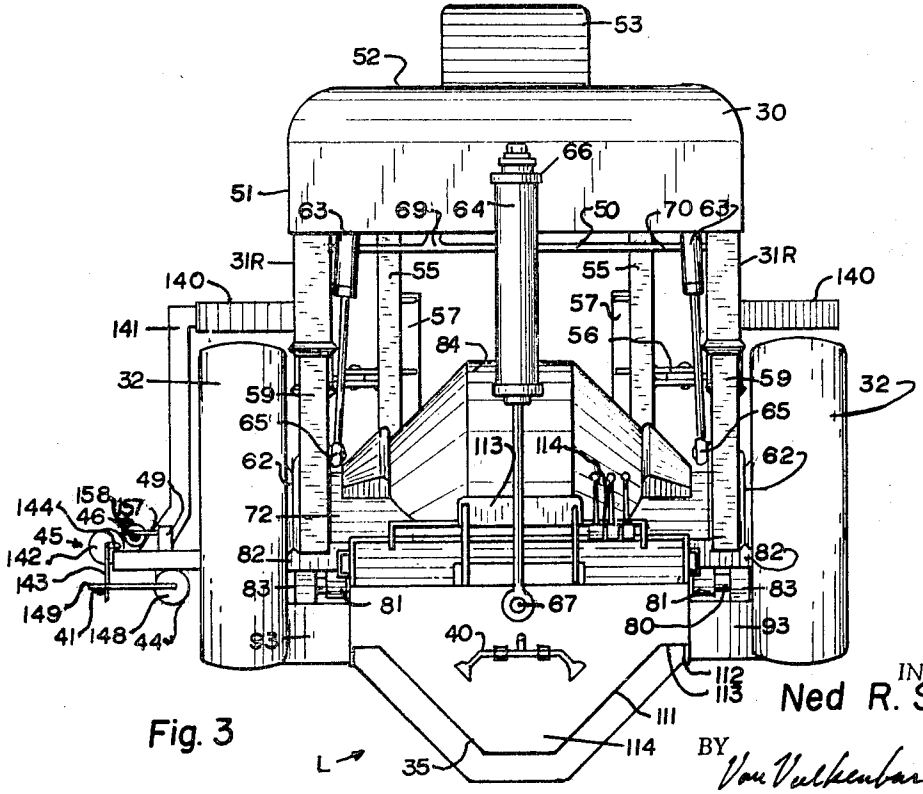


Fig. 3

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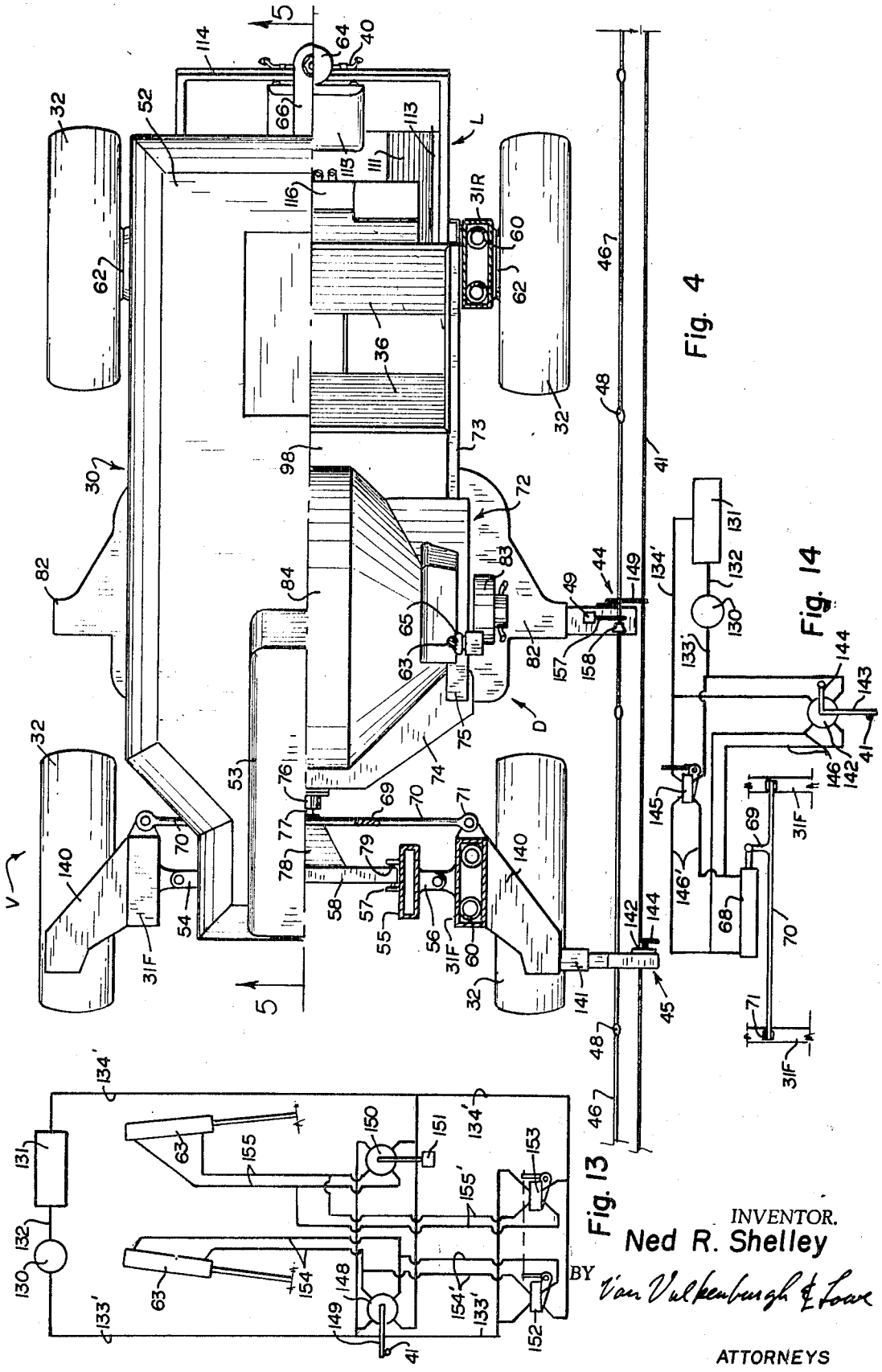


Fig. 4

Fig. 14

Fig. 13

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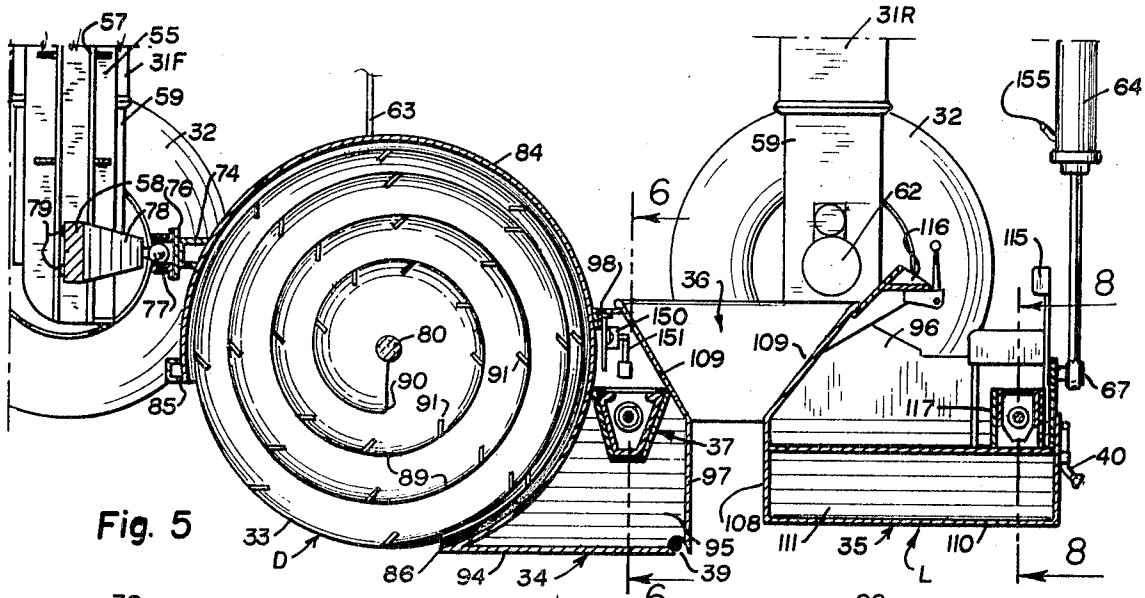


Fig. 5

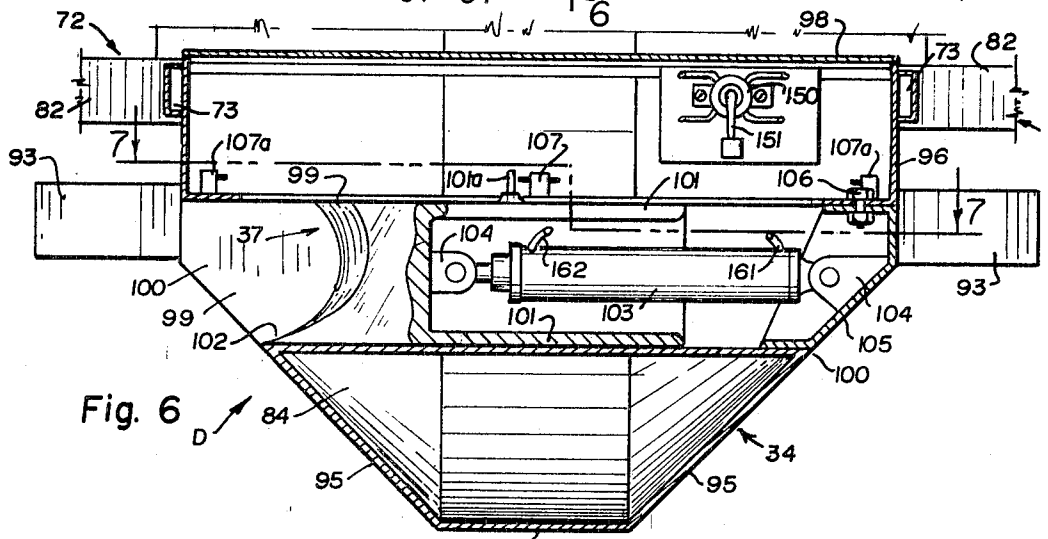


Fig. 6

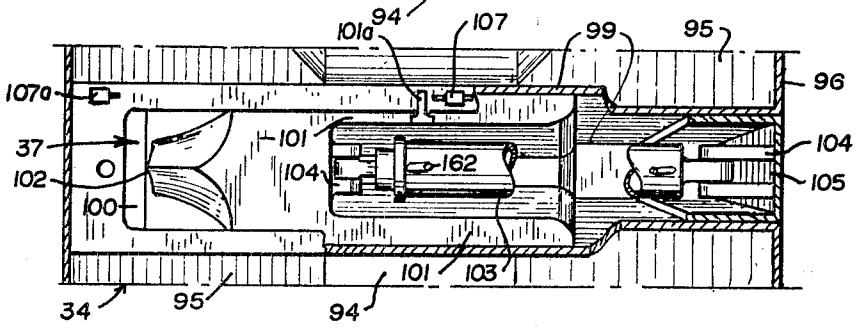


Fig. 7

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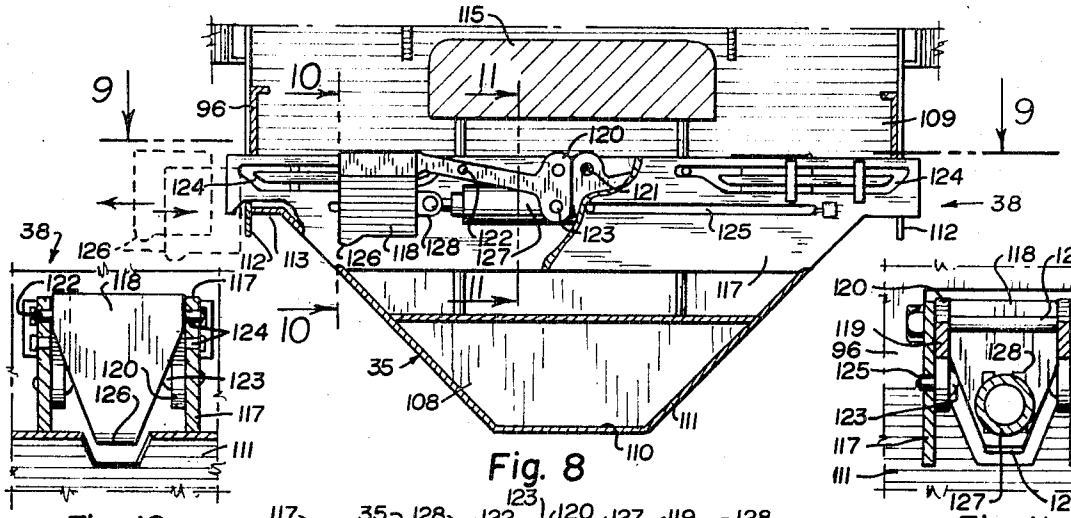


Fig. 8

Fig. 10

Fig. 11

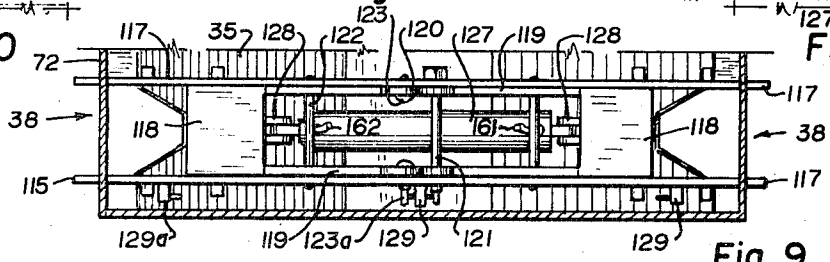


Fig. 9

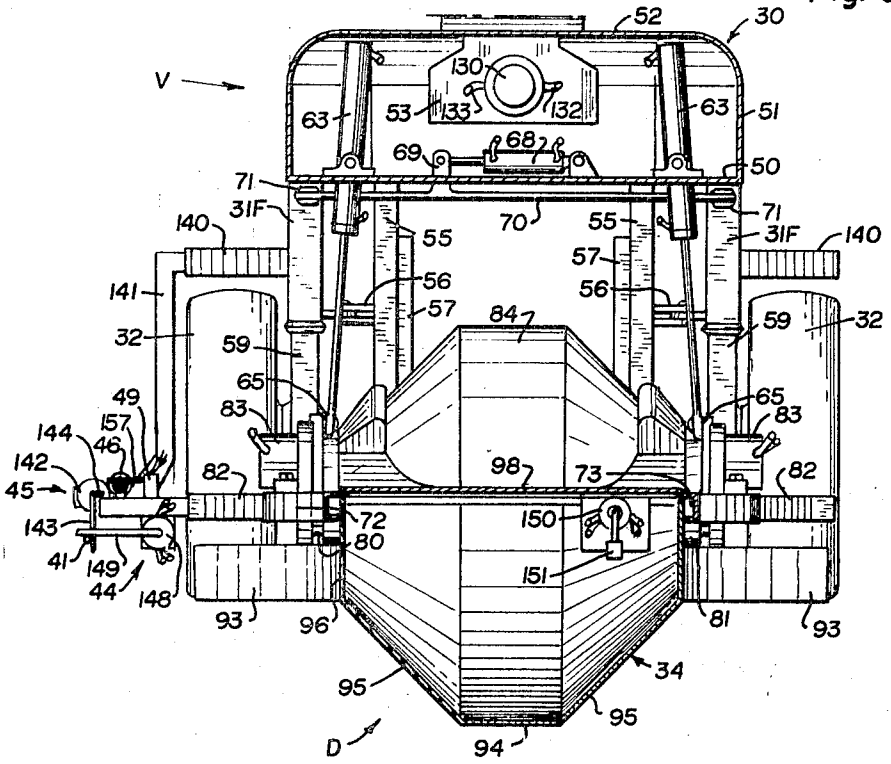


Fig. 12

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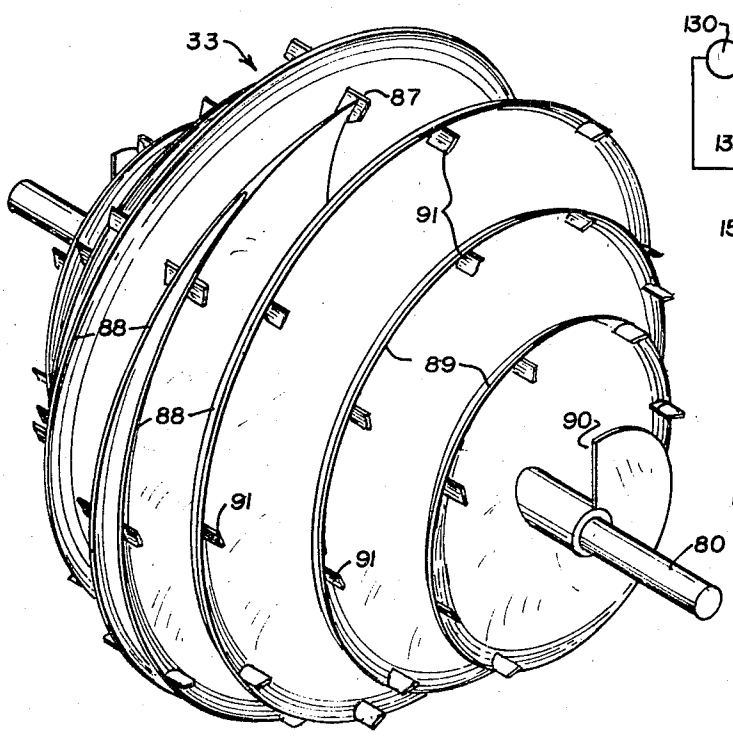


Fig. 16

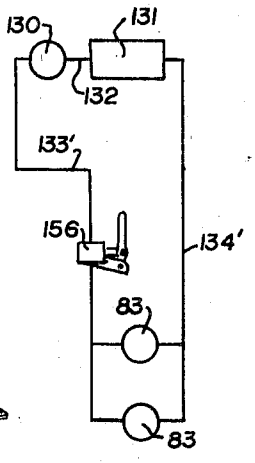


Fig. 17

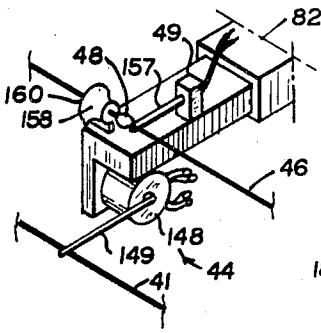


Fig. 18

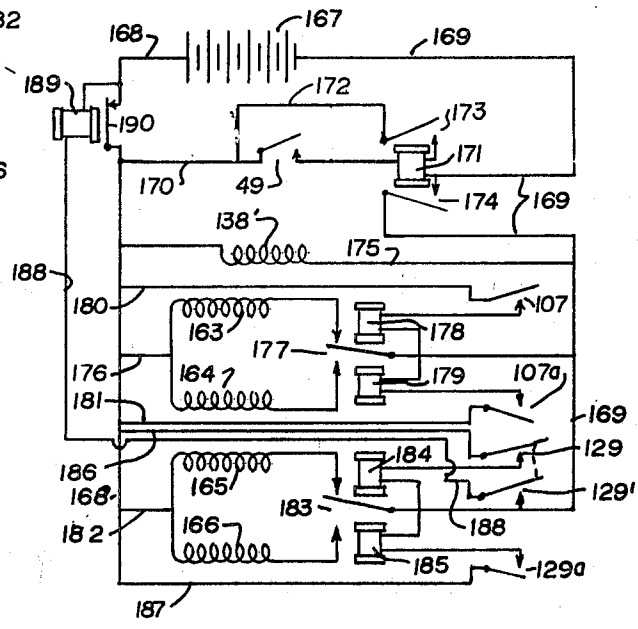


Fig. 20

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DITCH BUILDING APPARATUS

The present invention relates to apparatus and machinery for building irrigation ditches and more particularly, to an apparatus for digging and lining an irrigation ditch with concrete as a single operation.

A primary object of the invention is to provide a novel and improved apparatus which combines ditch digging and lining operations to facilitate the building of a finished irrigation ditch. As such, the invention will be hereinafter referred to as a "ditch building apparatus."

Another object of the invention is to provide a novel and improved ditch building apparatus which is adapted to dig a ditch and line it with concrete as a single continuous operation and in a manner which produces a ditch uniform in cross section and aligned precisely on grade along a selected, straight course.

There exists intense competition between irrigating land with sprinkler systems and by the use of ditches. Where a choice of system is to be made, it is to be noted that the first cost for an irrigation ditch system is usually less than that for a sprinkler system. However, the labor cost for operating an irrigation ditch system is usually substantially more than that for operating a sprinkler system. As a result of reduced operating costs, there has been a trend to install sprinkler systems wherever possible. This has brought about a growing need for improved irrigation ditch systems to compete with these sprinkler systems, for many land areas, especially areas in comparatively narrow strips, are not suitable for sprinkler systems.

As disclosed in my U.S. Pat., No. 3,410,094 issued Nov. 12, 1968, I developed a ditch lateral which is capable of irrigating a field at minimum cost providing the ditch is built as a series of reaches, each on a level grade, and with the upper portion of the ditch walls being well above the water level to constitute a freeboard thereof. Spaced notches are cut in this freeboard portion of the ditch. By blocking a selected reach of the ditch to raise the water level therein, a nearly level gradient is established and the flow of water from the notches is quite uniform. This permits distribution of water away from the ditch and across a field in a substantially uniform manner and alongside the reach of the ditch. The result significantly reduces the labor required by the irrigator. The popularity of this ditch construction has increased to such an extent that there is a demand for a more effective and more rapid system for building such ditches and especially, for building ditches which are precisely on grade. The present invention was therefore conceived and developed with this demand in view and comprises, in essence, a straddle vehicle carrying a digger to shape the trench forming the base of the ditch in the ground and slip-forms to form a concrete lining in the ditch as the apparatus moves along the course of the ditch. Also, during such movement notches are formed in a wall of the ditch by rams carried on the apparatus.

It follows that another object of the invention is to provide a novel and improved ditch building apparatus which is adapted to move along a prepared course, to dig a ditch, line it with concrete and to hold the grade of the ditch to such precision that outlet notches may be formed in a side of the ditch for use in field irrigation, to distribute water directly across the field alongside the ditch.

Another object of the invention is to provide a novel and improved ditch building apparatus which will dig and line a ditch along a precise grade as a continuous operation and at the same time form and finish side outlets precisely formed in the upper freeboard portion of a sidewall of the ditch.

Another object of the invention is to provide a novel and improved ditch building apparatus which digs a base for a concretelined, trapezoidal ditch as the apparatus moves along a selected course, and at the same time will effectively dispense the excess soil from the ditch base to each side of the ditch in a manner which minimizes subsequent levelling and grading operations to eliminate any windrows of excess soil at the sides of the ditch.

Other objects of the invention are to provide in a ditch building machine, a simplified automatic control system which correlates the several components thereof to simultaneously hold the machine on a given course, hold the ditch to a selected grade, hold the ditch transversely level and to properly locate notches along the course of the ditch.

Other objects of the invention are to provide a novel and improved ditch building apparatus which is a rugged and durable unit, neat and compact, and is capable of being used in various types of soil and earth.

With the foregoing and other objects in view, my present invention comprises certain constructions, combinations and arrangements of parts and elements as hereinafter described, defined in the appended claims, and illustrated in preferred embodiment by the accompanying drawing in which:

FIG. 1 is a side elevation view of the improved ditch building apparatus, illustrated as being lowered into the ground to an operative position, with the ground surface being indicated as in section at the ditch centerline, with a portion of concrete ditch lining being shown to depict a finished ditch rearwardly of the apparatus, with a rear wheel of the apparatus being removed to better illustrate portions of the apparatus which would be otherwise hidden from view, with dotted lines to show other parts hidden from view and with a dashed line to show the position of the ditch forming components when they are lifted out of the ground.

FIG. 2 is a front elevation of the apparatus as shown at FIG. 1, with a dashed line to indicate a portion of the ground surface.

FIG. 3 is a rear elevation of the apparatus as shown at FIG. 1, with the ground surface being indicated as in section rearwardly from the apparatus to illustrate the construction of a finished concrete lined ditch.

FIG. 4 is a partial plan and partial section of the apparatus as taken substantially from the indicated line 4—4 at FIG. 2.

FIG. 5 is a partial longitudinal section of the apparatus, as taken from the indicated line 5—5 at FIG. 4.

FIG. 6 is a partial transverse section as taken from the indicated line 6—6 at FIG. 5, but on an enlarged scale and illustrating specifically, a pocket forming ram.

FIG. 7 is a fragmentary sectional plan as taken substantially from the indicated line 7—7 at FIG. 6.

FIG. 8 is a transverse section of a portion of the apparatus as taken substantially from the indicated line 8—8 at FIG. 5, but on an enlarged scale and illustrating specifically, a notch finishing ram and with broken lines indicating certain movements of the ram.

FIG. 9 is a fragmentary, sectional plan as taken substantially from the indicated line 9—9 at FIG. 8.

FIG. 10 is a fragmentary sectional detail as taken from the indicated line 10—10 at FIG. 8, but on a further enlarged scale.

FIG. 11 is a fragmentary sectional detail as taken from the indicated line 11—11 at FIG. 8, but on a further enlarged scale.

FIG. 12 is a transverse sectional elevation as taken substantially from the indicated line 12—12 at FIG. 1 to illustrate particularly the actuators and controls for raising and lowering the ditcher and the actuator for steering the apparatus.

FIG. 13 is a diagram of the hydraulic circuits of the actuators and controls for raising and lowering the ditcher.

FIG. 14 is a diagram of the hydraulic circuits for operating the steering actuator.

FIG. 15 is a diagram of the hydraulic circuits for the driving wheels of the apparatus.

FIG. 16 is an isometric view of the excavating auger removed from the apparatus.

FIG. 17 is a circuit diagram of the hydraulic circuits for driving the auger.

FIG. 18 is an isometric fragmentary view of the control mechanisms which control the elevation of the ditch and which index the notch forming mechanisms.

FIG. 19 is a fragmentary sectional detail as taken from the indicated line 19—19 at FIG. 1, but on an enlarged scale to illustrate a water dispensing mechanism to condition the channel base for receiving concrete.

FIG. 20 is a circuit diagram representative of the electrical circuits needed to initiate actuation of the notch forming and notch finishing rams illustrated at FIGS. 6 through 11 responsive to movement of the apparatus past a notch indexing cord.

Referring more particularly to the drawing, the ditch building apparatus, essentially symmetrical from the longitudinal center axes, is suspended from and carried by a straddle vehicle V. The apparatus includes in combination with the vehicle, a leading digging section D and a trailing, lining section L. These sections merge together to extend longitudinally underneath the body of the vehicle V as a unitary structure.

The straddle vehicle V is formed as an elongated, boxlike body 30 which is carried upon four wheel posts including a front pair 31F pivoted to the body for steering and a rear pair 31R affixed to the body. The posts of each pair are spaced apart to straddle the digging section D and the lining section L and the ditch formed therewith. Each post is mounted upon a large diameter wheel 32 and the height of the posts and wheels is sufficient to permit the digging and lining sections to be lifted completely out of the ground and to be carried between the wheel posts and underneath the body 30 when the apparatus is not in use, as indicated by the dashed line at FIG. 1.

The digging section D includes a transversely shafted auger 33 whose flight edges define the outline of the trapezoidal ditch base with opposing left-hand and right-hand flights to move excavation dirt to each side of the ditch when the auger is rotating and the vehicle is moving forwardly as hereinafter further described.

The forming section F, trailing the auger, includes a trapezoidal base shoe 34 behind the auger which rides in the ditch trench dug by the auger and a smaller trapezoidal lining forming shoe 35 at the trailing end of the section. A concrete receiving hopper 36 is positioned between the base shoe and lining shoe as indicated in broken lines at FIG. 1. The forming section F includes further, a pocket forming ram 37 near the trailing end of the base shoe which is adapted to extend laterally into the wall of the fresh cut trench to form a side pocket therein, and a notch finishing ram 38 near the trailing end of the forming shoe which is adapted to form and finish a sidewall notch in the concrete lining of the ditch. A water dispensing channel 39 is extended about the trailing edge of the base shoe to wet earth after it has been smoothed by the base shoe to better condition the channel base for receiving concrete, and a spray nozzle 40 is located at the trailing end of the lining shoe to spray a curing compound upon the surface of the freshly formed concrete lining.

The course and grade of the ditch is established by a line 41 held under tension alongside the apparatus by suitable stakes 42 and removable auxiliary supports 43 to minimize sag. A sensitive grade indicator 44 at the digger section rides this line and a sensitive alignment indicator 45 rides this line adjacent to a front steering wheel 32. These and other indicator controls will be hereinafter further described. The notching of the ditch is indexed by a line 46 alongside line 42, held by suitable stakes 47. Lugs 48 are spaced along this line at the same spacing or at one-half the spacing of the spacing between the rams 37 and 38. An indicator switch 49 is operated at the selected spacings, all as are hereinafter further described in detail.

The body 30 of the straddle vehicle is formed as a floor section 50 enclosed by walls 51 and a cover 52. As such, it constitutes a compartment to carry a motor 53 which is suitable for operating the apparatus as through a hydraulic system. Also, the compartment will hold tanks, not shown, for fuel, ballast, water, curing compounds and a reservoir for hydraulic fluid. Also, the various hydraulic control cylinders for the apparatus are mounted onto this body as will be described.

The width of the central and rearward portion of the body is the same as the transverse spacing between the rear wheel posts 31R, but the front end portion is narrowed to permit each front wheel post 31F to upstand alongside this narrowed body portion and to be connected thereto by a vertically axised kingpin hinge 54. A heavy, rectangular pull-arm 55 depends from each side of this narrowed body portion, alongside each wheel post, to provide for a surface to mount a second kingpin hinge 56 at a substantial spacing below the first-mentioned hinge 54. Vertical guideways 57 are affixed to the inner surface of each arm 55, in spaced opposition with the other, and a horizontally disposed, pull beam 58 is carried in these guideways to connect with the front end of the digger section as hereinafter described.

The wheel posts 31F and 31R are formed as heavy, rectangular, tubular members. The rearward posts 31R depend from the floor portion at each side of the body and the forward posts 31F upstand alongside the narrowed portion of the body to be connected thereto by kingpin hinges as described. A rectangular, tubular extension section 59 telescopically fits into and depends from each post 31F and 31R to carry the wheels 32. Each extension is held in position by springs 60 within the base section to provide individual, vertical movement of each wheel as the apparatus moves over irregular ground surface. The limit of such movement is restricted by a pin 61 affixed to a portion of an extension section within its post and extending through a slot 62 in the post, as illustrated at FIG. 1.

The lower end of each depending post extension 59 carries a suitable hydraulic motor 62 having its drive shaft cantilevered from the side of the post for connection with a wheel 32. The motors 62 of the four posts are adapted to operate in unison to provide a four-wheel drive for the vehicle as hereinafter further described. The wheels 32 are preferably large diameter wheels with pneumatic tires, similar to large tractor wheels and tires.

The digger-liner sections are suspended from the body 30 by the extended piston rods of a pair of hydraulic cylinders 63 above the auger 33 and by a third cylinder 64 at the trailing end of the body. The front end of the digger section is also attached to the pull beam 58 carried on the arms 55 at the front of the body. EAch hydraulic cylinder 63 is attached to the floor 50 at a side of the body above the auger and its downwardly extended piston rod connects with a pin 65 mounted upon a frame portion at the side of the digger section D. The rear cylinder 64 is attached to a trailing end of the body from a suitable bracket 66 and this cylinder and its piston rod extends downwardly from the bracket to connect with a pin 67 outstanding from the trailing end of the liner section L. The suspension cylinders 63 above the auger are operative to raise and lower and to transversely level the ditch and to hold it on grade as it is being dug by controls hereinafter described. The rear cylinder 64 is not needed to control the operation of the digger and lining sections and need function only when the digger and liner sections are to be lifted out of the ditch as when the apparatus is not in use. The controls for operating this cylinder is thus comparatively simple, as hereinafter described.

A steering cylinder 68 is transversely mounted upon the floor 50 within the body section just behind the forward steering post 31F and its piston rod is connected with a finger 69 which depends through a slotted opening in the floor of the body and, in turn, connects with a steering bar 70 extending transversely across the apparatus and connecting with knuckle pivots 71 at the rear side of each steering post 31F. The steering cylinder 68 is operated by controls to steer the vehicle and to hold it in alignment when a ditch is being dug, as will be hereinafter further described.

The digger section D and the liner section L are interconnected by a framework 72 having longitudinal members 73 at each side of these sections and a yoke 74 extending across the leading end or front of the digger section. Preferably, the yoke is positioned above the longitudinal members 73 and the interconnection between the two components is provided by a vertically disposed frame plate 75 at each side of the digger. The leading end of the yoke carries a socket 76 at its center to

receive a connecting ball 77 which is mounted upon a cantilevered, pyramideshaped arm 78 outstanding from the pull beam 58. The beam 58 is carried in the guideways 57 as heretofore mentioned, and wheel rollers 79 may be provided at each end of this beam 58 to minimize the frictional resistance of the beam to vertical movements. It follows that the digger and forming sections have substantial freedom of movement within the vehicle V, being restrained only by the ball 77 to follow the forward movement of the vehicle and to remain at the center of the forward end of the vehicle V. Otherwise, the digger and forming sections are free to rotate and to swing about this ball 77 to any suitable position as established by the suspension cylinders 63.

The digger section carries the trapezoidal-shaped auger 33 upon a transversely disposed shaft 80. The shaft, in turn, is mounted upon a bearing 81 at each side of the section, the bearings being secured to the underside of shelves 82 which outstand from the longitudinal frame members 73 adjacent to the auger. A hydraulic motor 83 is carried upon at least one shelf 82 to connect with one end of the shaft 80 and preferably, two motors are used, one being mounted upon each shelf. The motor 83 is operated by controls, hereinafter described, to rotate the auger 33 so that the portion of the auger, beneath the shaft, will move forwardly and against the direction of travel of the vehicle.

A substantial portion, and approximately three-fourths of the auger 33 is enclosed by a circular hood 84 which is trapezoidal in section to embrace the trapezoidal-shaped auger with sufficient snugness as to facilitate lateral movement of earth by the flights of the auger. This hood extends from a reinforced, forward, horizontal edge 85 below the framework yoke 74, thence upwardly between the yoke, thence over the top of the auger, thence downwardly at the rearward side of the auger and terminating as a vertical edge 86 at the bottom of the auger. This edge 86 merges with and becomes the leading edge of the trapezoidal undersurface of the base shoe 34.

The auger 33 is formed as left hand and right hand flights as illustrated at FIG. 16. Each commences at a center point 87 of the shaft and extends laterally therefrom as heretofore mentioned. Each flight is illustrated as a single-pitch auger screw, however, if desired, a double-pitch auger screw may be used. The edge of the auger flights is formed to dig a trapezoidal ditch having a flat bottom portion at the center and sloping sidewall portions at each side of the bottom as mentioned. Accordingly, the spiral of each section of the auger will be formed generally as a helix 88, at the center where the flat bottom section of the ditch is cut and as an involute 89 to the outside termination point 90, in the sloping portion of the ditch. The flight of each side of the auger is preferably dished to facilitate moving earth outwardly from the center of the ditch as it rotates. The cutting action of the auger is facilitated by an array of chisels 91, welded at the peripheral edge of the auger flight as illustrated at FIG. 16, which are arranged in a staggered manner so that all portions of the ditch will be planed by at least one chisel each time the auger revolves.

The frame plate 75 extends below the frame members 73 at the termination of each auger and a circular opening 92 is formed in this plate to facilitate the discharge of earth from the auger. A deflector 93 extends outwardly from the plate 75 at the rearward side of this opening to move earth discharged therefrom laterally and form a comparatively smooth path for the rear wheels of the vehicle as the vehicle moves forwardly, with windrows of discharged earth being out of the way of the rear wheels.

The base shoe 34 commencing at the terminal edge 86 of the hood and extending thence rearwardly, consists of a longitudinal bottom plate 94 and an inclined sideplate 95 at each side of the bottom plate to define the trapezoidal base section of the ditch. A longitudinal wall portion 96 upstands from the outer edge of each sideplate 95 to connect with the frame members 73 thereabove. The rear end of this base shoe 34 is crossed by a transverse wall 97 which forms the leading wall of the concrete hopper. To complete the base shoe unit, a cover plate 98 is placed over the compartment within the base shoe which lies between the auger hood 84 and the rear wall 97.

The transversely disposed pocket ram 37 is trapezoidal in form and is carried in a trapezoidal guideway 99, formed by plates and angles to extend transversely across the base shoe 34 and to an opening 100 in each sidewall of the base shoe at the top of each sideplate 95 and at a portion of the juncture with its vertical wall 96 thereabove.

The ram 37 is formed as a head portion having arms 101 extended rearwardly from this head portion to support it when it is projected through the openings 100 and from the side of the base shoe. The head has a plow-shaped, curved surface with a sharpened lip 102 at its bottom edge. It is thus adapted to cut and displace earth as the ram moves outwardly from the way 99 and the length of the ram is sufficient to remain within this way and at the same time cut a lateral pocket into the earth at the top of the ditch base. Concrete in the hopper 36 will fill this pocket with concrete and a lateral ditch notch may then be formed as hereinafter described. The ram 37 is operated by a cylinder 103 having its piston secured to lugs 104 on the head of the ram and its base end secured to opposing lugs 104 on an abutment plate 105. This abutment plate is formed to enclose the sidewall opening 100 opposite the leading end of the ram and is held in position in the way 99 by a bolt 106. This cylinder is of a double-acting type adapted to extend and retract by an electrically actuated four-way valve, not shown, but hereinafter further described. The valve is operated by limit switches 107 and 107*a* on the way 99 which contact a finger 101*a* at each end of the travel of an arm 101. It is to be noted that this ram and its abutment may be reversed within the way 99 to cut pockets at either side of the ditch and accordingly, an extra limit switch 107*a* is provided for this purpose.

The hopper 36, interposed between the base shoe 34 and lining shoe 35, includes the vertical plate 97 forming the rear wall of the base shoe, an opposed plate 108 which is the leading wall of the forming shoe and sloping wall portions 109 above these walls 97 and 108. The sides of the hopper are formed by the vertical wall plates 96 above the sloping portions of the shoes. This hopper is adapted to receive a charge of concrete from time to time to permit the concrete to flow between the sloping walls 109, into the narrower portion between walls 97 and 108 to form the concrete lining for the ditch as the vehicle moves along its course.

The trapezoidal forming shoe 35 is proportioned to provide for concrete lining in the wall of the ditch of any desired thickness, such as three inches. This forming shoe includes a flat bottom 110, inclined sidewalls 111 and a continuation of the upstanding wall sections 96 connecting with frame members 73 to support the sidewalls 111. However, the wall sections 96 do not connect directly with the inclined walls 111, but extend below the top edge of the walls as overhanging lips 112 which form the outward, vertical wall portions of the curbs of the ditch lining. A flattened section 113 between each lip and the sloping sideplates 111 forms the tops of the ditch curbs. To complete this lining shoe, a rear wall 114 encloses the bottom 110 and sideplates 111.

The compartment within the forming shoe provides a suitable operator's compartment. A chair 115 is mounted at the center and at the rear end of the compartment and an operator's control board 116 is mounted forwardly thereof upon inclined plates forming a continuation of the hopper mouth 108 above the frame members.

The transverse notch ram 38 is carried within a frame 117 consisting of two vertical, parallel plates and extending transversely across the forming shoe beneath the chair. The ram is conveniently formed as a dual unit for cutting notches at either side of a ditch without having to reverse the units. As such, each ram consists of a head portion 118 and arms 119 which extend from the head and to the center of the frame 117 when the ram is in a normally retracted position at the edge of the notch opening in the side of the shoe as best illustrated at FIG. 9. Each arm 119 extends from the top of the ram head 38

to terminate as an enlargement **120** at the center of the section. It is contemplated that one ram **38** will be locked in this retracted position by inserting a lock bolt **121** through suitable holes in the frame plates **117** and in the enlargement **120**. Each ram also includes sets of pins including an outer pin **122** near the head of the ram and an inner set of pins **123** at the base of the enlargement **120**. These pins, extending from each arm **119**, are adapted to slide in guideways formed in the plates **117**. A first guideway **124** for each outer pin **122** is formed as a circuitous path including an upper horizontal reach adjacent to and paralleling the upper edge of its frame plate **117**, and a lower horizontal reach connecting with each end of the upper reach. The inner set of pins **123** are adapted to move in a single guideway **125** which parallels the guideway **124**, but is laterally offset therefrom as illustrated at FIG. **8**.

In operation, the outward movement of the notch ram **118**, which is not locked in position by bolt **121** is with the pin **122** in the upper reach of the guideway **124** and the return movement is with this pin **122** in the lower reach of the guideway **124**. The outward movement forms an opening through the concrete deposited in the side pocket in the earth formed by a ram **37**, while the inward movement of this ram **118** finishes off and shapes the concrete into a notch by dropping to a lower level as the pin **122** moves in the lower reach of the way **124**. A lip **126** is formed at the lower edge of this ram **118** to facilitate this finishing action.

The ram is operated by a cylinder **127** having each end connected to a lug **128** at the inward side of the ram head **118**. This cylinder is of a double-acting type adapted to extend and retract by an electrically actuated four-way valve, not shown, but further hereinafter described. The valve is operated by limit switches **129** and **129*a*** on a frame member **115** at each end of the travel of a finger **123*a*** on a pin **123**, the limit switches being located at the center and at both sides of the unit for selective operation of either ram.

In the embodiment herein described, the operative components are driven by a single-hydraulic system and the motor **53** includes a pump **130**, shown at FIG. **12**, which is connected to a suitable reservoir **131** indicated in broken lines at FIG. **1** as a supply line **132**. A pressure line **133** extends from the pump to divide into several branches, indicated at **133'**, to the drives and cylinders of the several operative components, and return branches **134'** from these components join as a return line **134** which extends to the reservoir to complete the circuit at the pump. The several operative components include the motor drive **62** for the wheels **32**, the steering control cylinder **68** which guides the vehicle, the cylinders **63** which elevate and hold the digger and liner sections level, the motor **83** which drives the auger, the cylinders **103** and **127** which operate the notch forming and notch finishing rams and the cylinder **64** which is used to assist in elevating the rear end of the liner section L. These components, herein described as being operated from a single source of power, may also be operated from individual power sources, if desired, and the notch forming rams may be air operated instead of fluid operated, if desirable. However, the controls hereinafter described for these systems will be essentially the same whether operated from individual hydraulic power sources or from a single pump.

This hydraulic circuit to drive the vehicle, illustrated diagrammatically at FIG. **15**, includes a pressure line **133'** and return line **134'** connecting with the pump **130** and reservoir **131**. The pressure line **133'** and return line **134'** extends to a manually operated, four-way control valve **135**, and opposing feed lines **136** extend from this valve to branches **136'** to each of the hydraulic motors **62** of the wheels **32**, as heretofore described, although FIG. **15** shows only one branch of the feed lines **136'** to one motor **62** with other branches **136'** being indicated by arrows. The four-way manual control valve **135** is conventional and is of a type which is off at one position of its handle, and which may be shifted to direct pressure fluid through a first feed line **136** to return through the other feed line as to drive the vehicle forwardly. A shift to another position reverses the flow in the feed lines to reverse the motors **62**. To supplement this basic circuitry, a normally closed, manually operated bypass valve **137** may be installed in a shunt line between the feed lines **136** to prevent movement of the motors **62** regardless of the position of valve **135**, and a solenoid-operated valve **138** may be installed in a shunt line between the feed lines to open to stop the motors **62** responsive to closing the circuit of the solenoid **138'** of the valve. This solenoid valve **138** operates in conjunction with notch forming mechanisms, hereinafter described.

The vehicle V must be capable of being steered either manually or automatically. The automatic system is carried upon a framework **140** outstanding from each steering post **31F** above the wheel **32** to carry a post **141** which depends alongside the wheel. This post, in turn, supports the alignment indicator **45** heretofore mentioned. This indicator includes a sensitive, four-way cylinder valve **142** operable by a pendulum arm **143** which hangs downwardly to contact the guide line **41**. This arm **143** is provided with a small balance arm **144** to hold the arm against one side of the line **41** with a light pressure and to permit it to swing either direction when the vehicle moves out of alignment with the line **41**. This operates the valve **142** to actuate cylinder **68** to realign the steering wheels with line **41**.

The hydraulic circuit to steer the vehicle, illustrated at FIG. **14**, includes a pressure line **133'** and return line **134'** connecting with the pump **130** and reservoir **131**. The lines **133'** and **134'** connect with the cylinder valve **142**. Also, the lines **133'** and **134'** extend to a normally closed, manually operated four-way valve **145**. Feed lines **146** extend from the four-way cylinder valve **142** and to opposite ends of the cylinder **68**. Likewise, feed lines **146'** extend from the manual valve **145** to connect with the lines **146** at the cylinder. When the manual valve **145** is closed, steering is accomplished by movements of the pendulum arm **143** operating the valve **142** to flow fluid through one feed line **146** to one side of the cylinder **68**, arranged so that it shifts the steering bar **70** to bring the vehicle into alignment with the line **41**.

The normally closed manual valve **145** is opened in one direction to flow pressured fluid through one line **146'** and opened in another direction to flow fluid through the other line **146'** and thus steer the vehicle. This manual valve **145** and the lines **146'** will have a substantially greater capacity than the valve **142** and feed lines **146** so that when the manual valve is in operation, it dominates the action of the automatic valve.

The digger section and liner section of the vehicle must remain at a selected elevation and must remain transversely level as the vehicle moves along its course. This is accomplished by the grade indicator **44** controlling the adjacent support cylinder **63** and a level control controlling the other at the opposite cylinder **63**. The grade indicator **44** includes a sensitive, four-way cylinder **148** mounted upon a shelf **82** in a position where its actuator arm **149** outstands to rest upon the guide line **41**. The level control is a similar, sensitive, four-way cylinder valve **150** affixed to the body of the digger section as at the position shown at FIGS. **6** and **12**. This valve **150** has a weighted arm **151** which serves as a pendulum and is at its neutral position when the apparatus is level.

The hydraulic circuit to operate the two cylinders **63**, illustrated diagrammatically at FIG. **13**, includes a pressure line **133'** and a return line **134'** connecting the pump **130** and reservoir **131** with the cylinder valves **148** and **150**. Branches of the lines **133'** and **134'** also connect with normally closed, manually operated four-way valves **152** and **153** which are located at the control panel to permit operation of the cylinders **63** to raise the digger section completely out of the ground as when the apparatus is not in use. A pair of feed lines **154** extend from the cylinder valve **148** to opposite sides of the cylinder **63** adjacent to the grade indicator control **44** and it follows that slight movements of the arm **149** will extend or retract the piston of cylinder **63** to compensate for misalignment of the arm **149** with respect to the guide line **41**. A pair

of feed lines 155 connect with the four-way valve 150 to extend to opposite ends of the other cylinder 63 so that movements of the pendulum arm 151 from its normal position whenever the digger section tips sidewise, will operate cylinder 63 to extend or retract its piston to level the apparatus. A pair of feed lines 154' extend from a manual valve 152 to connect with the feed lines 154 to operate the first mentioned cylinder 63. A pair of feed lines 155' extend from the manual valve 153 to connect with the feed lines 155 to operate the second mentioned cylinder 163 manually.

The two manual valves 152 and 153 may be mechanically interlinked to operate in unison since it is normally desired to lift both sides of the digger section simultaneously and preferably, the capacity of these manual valves will be much greater than the capacity of the cylinder valves 148 and 150 so that a more rapid lifting action is possible. When the digger and liner sections are lifted out of the ditch, the cylinder valves 148 and 150 must remain in the off position to prevent the sections from being lowered as by a slow leak through one of these valves, especially if the arm 149 of valve 148 were permitted to deflect excessively. A simple manual valve, not shown, may be inserted into each line 154 and 155 adjacent to the valves 148 and 150 for this purpose.

Whenever the digger section is lifted out of the ditch, the trailing end of the liner section must also be lifted out of the ditch as by cylinder 64. The hydraulic circuit for this cylinder is not illustrated since it is conventional and manually operated. A pressure branch line 133' and a return line 134' from the pump 130 and to the reservoir 131 connect with the manual valve, not shown, which, in turn, includes feed lines 155 connecting with the cylinder 64 as shown at FIG. 1. The manually operated valve is of a conventional type having a handle which may be shifted to a first position to close off lines 133' and 134' but to interconnect the feed lines 155; shifted to a second position to direct the pressure line 133' into the lower feed line of the cylinder 155 and shifted to a third position to close off lines 133' and 134' and at the same time, close off the feed lines 155. The first position of the valve is a normal operating position where the piston of this cylinder 64 floats as when the apparatus is digging and lining a ditch. The second position lifts the liner section L and the third position holds the liner section in its lifted position.

The auger 33 is rotated by the motors 83 heretofore described and this rotation is controlled manually. The hydraulic circuit to operate these auger motors 83, illustrated diagrammatically at FIG. 17, includes a pressure line 133' and a return line 134' connecting the pump 130 and reservoir 131 with the motors 83. A simple, manual, offon valve 156 is provided in the line 131 to open to run the motors and to close to stop the motors. Adjustment of flow through these lines may be effected at the valve to regulate the speed of the motors.

The notch forming apparatus operates responsive to a lug 48 on the indexing line 46 moving against the actuator finger 157 of switch 49 to momentarily close, or pulse, the switch 49. The switch 49 is mounted upon an extension shelf 82 and a guide orifice 158 through which the line 46 passes, is also carried upon this shelf to hold the line in position with respect to the switch. The lugs 48 are spaced the same as the spacing between the pocket forming ram 37 and notch finishing ram 38 so that the two rams may operate in unison with the notch finishing ram moving into a pocket previously formed by the pocket ram. The cylinders 103 and 126 of the two rams are each double acting. Each connects with a hydraulic extension line 161 and a retraction line 162. The lines are as shown at FIGS. 6 and 8. The lines 161 and 162 for each cylinder extend to a solenoid-operated, four-way valve, not shown, and branches of the pressure line 133 and the return line 134 of the hydraulic power supply also connect with this valve. The four-way, solenoid-operated valves are conventional. Each includes two solenoid coils: one coil is energized to open the valve and the other solenoid coil energized to close it. These coils are indicated at FIG. 20 as 163 and 164 for the cylinder 103, and 165 and 166 for the cylinder 126.

FIG. 20 is a circuit diagram for operating the solenoid valves and other controls to actuate the pocket and notch forming rams responsive to a momentary closing of the switch 49 by a knob 48. A suitable power source such as a battery 167, provides for main leads 168 and 169. These leads are shunted by several branches to control solenoids as now described.

A first shunt lead 170 includes the normally open switch 49 and a relay coil 171. A second shunt lead 172 parallels the lead 170 and includes a normally open relay switch 173 which connects with the relay coil 171 to form an interlock. A momentary closure of switch 49 momentarily energizes relay 171 to close switch 173 which then holds the coil 171 in its energized state. The main lead 169 includes a normally open relay switch 174 which is closed whenever relay coil 171 is energized and when this switch closes, the other circuits become operative.

A shunt lead 175 includes the solenoid 138' which is energized to open the valve 138 in the driving circuit illustrated at FIG. 15. This stops movement of the vehicle while the notch operations are under way.

A shunt lead 176 bifricates to carry the pocket-ram-extending-solenoid coil 163 and the pocket-ram-retracting-solenoid coil 164. The leads from solenoid coils 163 and 164 connect with a two-way relay switch 177 of the type having an arm which will shift to close with either solenoid 163 or 164. This switch is actuated by relay coils 178 and 179. The relay coil 178 is in a shunt circuit 180 which includes the normally open limit switch 107, which is momentarily closed when the ram 37 is fully retracted. This momentary closure of the limit switch 107 will thus throw the arm of switch 177 to contact with The lead of solenoid coil 163 to thereupon produce an extension of the ram 37. The coil 179 is in a shunt lead 181 which includes the normally open limit switch 107*a* which is momentarily closed when the ram 37 is fully extended. This momentary closure of limit switch 107*a* will thus throw the arm of switch 177 to contact with the lead of solenoid coil 164 to thereupon produce a retraction of the ram 37.

A shunt lead 182 bifricates to carry the notch-finishing-ram-extending-solenoid coil 165 and the notch-finishing-ram-retracting-solenoid coil 166. The leads from solenoid coils 165 and 166 connect with a two-way relay switch 183 of the type having an arm which will shift to close with either solenoid coil 165 or 166. This switch is actuated by relay coils 184 and 185. The relay coil 184 is in a shunt circuit 186 which includes the normally open limit switch 129 which is momentarily closed when the ram 38 is fully retracted. This momentary closure of the limit switch 129 will thus throw the arm of switch 183 to contact with the lead of solenoid coil 165 to thereupon produce an extension of the ram 38.

The coil 185 is in a shunt lead 187 which includes the normally open limit switch 129*a* which is momentarily closed when the ram 38 is fully extended. This momentary closure of the limit switch 129*a* will thus throw the arm of switch 183 to contact with the lead of solenoid coil 164 to thereupon produce a retraction of the ram 38.

A cut out circuit 188 connects with the main lead 168 adjacent to the battery and includes the relay coil 189. This circuit also includes a second normally open switch 129', operatively linked to the limit switch 129 to close simultaneously therewith or a short time thereafter. The main circuit 168 includes a normally closed relay switch 190 which is opened whenever the relay coil 189 energizes, and when this switch 190 opens, all of the circuits are deenergized. The notch-finishing-ram 38 will be timed to operate slightly slower than the pocket forming ram and accordingly, when the cut out switch 129' momentarily closes, the arm of the switch 177 will have contacted coil 163 and the arm of switch 183 will have contacted coil 165 to initiate extension of the rams. However, this extension movement cannot occur until a new cycle commences, after the vehicle moves forward to have another lug 48 contact the arm 157 of switch 49. Then the switch 49 again closes to effect an interlock and close switch 174 to energize

the main circuits. Thereafter, the extension and retraction cycles will occur while the vehicle is immobilized until the switch **129'** momentarily closes to open switch **190** to deenergize all circuits so that switch **174** opens to prevent further action until switch **49** is again closed. The circuit is completed by a normally closed, manually operated switch **191** in the shunt lead **170** which will render the rams inoperative, as where it is not desired to have notches in the ditch.

I have now described my invention in considerable detail. However, it is obvious that others skilled in the art can build and devise alternate and equivalent constructions which are nevertheless within the spirit and scope of my invention.

I claim:

1. The combination with a ditch building apparatus adapted to dig a ditch along a selected course and to line the same with concrete, having

a. a vehicle having a body mounted upon upright wheel-mounted post means spaced apart sufficiently to straddle a ditch course, a suspension means depending from the body and a pulling means at the leading end of the body;

b. a digger means carried by the suspension means and held by the pulling means adapted to dig a trench as the vehicle moves along the ditch course and to discharge earth from the trench excavation laterally therefrom:

c. a concrete receiving hopper connected to and trailing the digger means to receive and to hold a charge of concrete and to deposit the same into the aforesaid trench;

d. a forming means connected to and trailing the hopper to dispense concrete from the hopper within the trench as a lining to form a finished ditch;

e. said suspension means including an extendable and retractable actuator means at each side of the digger means to lower and raise each respective side of the digger means; of:

an adjustment means adapted to selectively actuate each actuator means to hold the digger means at a selected grade elevation and transversely level regardless of the position of the vehicle as it moves along the course of the ditch and over uneven ground, wherein said adjustment means includes:

a. a guide line means disposed alongside the ditch course paralleling the selected grade elevation of the ditch;

b. a control means mounted upon the digger means and having a control arm extending therefrom to contact the aforesaid guide line means to shift vertically and to one side or the other whenever the elevation of the digger changes with respect to the guide line means, said control means being operatively interconnected with one of said actuator means to extend or retract the actuator means responsive to movements of the control arm to render the actuator means inoperative whenever the digger means is at the selected grade elevation and the arm at a neutral position, but to compensatively render the actuator means operative whenever the digger means is not at the selected position and the arm is moved from the neutral position to thereby return the digger means to the selected grade elevation.

2. In the organization set forth in claim **1**, wherein the said actuator means is a double acting hydraulic cylinder and:

said control means is a four-way control valve mounted upon the digger means operatively connecting with the cylinder and having a control arm extending therefrom to rest upon the aforesaid guide line means to shift vertically to open one side or the other whenever the elevation of the digger changes with respect to the guide line, said valve being operatively interconnected with said cylinder with the arm at a neutral position with the valve being closed whenever the digger means is at the selected grade elevation, but with the arm being shifted from the neutral position to open the valve whenever the digger means shifts from the selected grade elevation, said valve opening thereby compensatively actuating the cylinder to return the digger means to the selected grade position.

3. In the combination set forth in claim **2**, wherein the other of said actuators is a second double-acting hydraulic cylinder, and said adjustment means includes:

a second four-way control valve mounted upon the digger means operatively interconnected and with the said second cylinder arm having a weighted control arm depending therefrom as a pendulum, said valve being at a neutral, closed position when the digger means is transversely level, but swingable from this neutral position responsive to a tilt of the digger means to open and to compensatively actuate the second cylinder to return the digger to the aforesaid transverse level position.

4. In a ditch building apparatus adapted to dig a ditch along a selected course and to line the same with concrete, having

a. a vehicle having a body mounted upon upright wheel-mounted post means spaced apart sufficiently to straddle a ditch course, a suspension means depending from the body and a pulling means at the leading end of the body;

b. a digger means carried by the suspension means and held by the pulling means adapted to dig a trench as the vehicle moves along the ditch course and to discharge earth from the trench excavation laterally therefrom;

c. said suspension means including an extendable and retractable actuator means at each side of the digger means to lower and raise each respective side of the digger means;

d. an adjustment means adapted to selectively actuate each actuator means to hold the digger means at a selected grade elevation and transversely level regardless of the position of the vehicle as it moves along the course of the ditch and over uneven ground;

e. a concrete receiving hopper connected to and trailing the digger means to receive and to hold a charge of concrete and to deposit the same into the aforesaid trench; and

f. a forming means connected to and trailing the hopper to dispense concrete from the hopper within the trench as a lining to form a finished ditch, wherein said pulling means includes:

a. a guiding means depending from the forward end of the vehicle;

b. a holding member carried in the guide means to shift vertically; and

c. a flexible connector at the center of the holding member interconnecting the holding member with the center of the forward end of the digger, said holding member and connector permitting the digger means to be shifted vertically and to swing about the connector with respect to the position of the vehicle.

5. In the combination set forth in claim **4**, wherein:

said guide means comprises a pair of upright arms symmetrically spaced from the longitudinal axis of the vehicle having opposing guideways therein;

said holding member extends transversely between the arms and into the guideways to shift therein; and

said flexible connection includes a ball and socket joint.

6. In a ditch building apparatus adapted to dig a ditch and line the same with concrete, and comprising, in combination:

a. a vehicle, including a suspension means adapted to move along the course of the ditch;

b. a digger means supported by the suspension means adapted to dig a trench as the vehicle moves along the ditch course and to discharge earth from the trench excavation laterally therefrom; and

c. a concrete receiving hopper connected to and trailing the digger to receive and to hold a charge of concrete and to deposit the same into the aforesaid trench; and

d. a forming means connected to and trailing the hopper to dispense concrete from the hopper within the trench as a lining to form a finished ditch, wherein said forming means comprises a longitudinally extended, platelike structure shaped to the transverse section of the finished

ditch having a leading, closed wall defining the trailing edge of the aforesaid hopper.

7. In the organization set forth in claim 6, wherein said digger means comprises:

a transversely axised auger, shaped to define the ditch-trench cross section and having flight means on the auger adapted to shift earth excavated from the ditch laterally therefrom responsive to rotation of the auger; and

means to rotate the auger with the leading portion of the under edge of the auger moving forwardly and upwardly against the earth in a direction the same as the direction of movement of the vehicle.

8. In the organization set forth in claim 7, wherein:

said auger is formed as two opposing flights, each commencing at the center of the digger and extending laterally toward opposite edge portions of the ditch, with the flight pitch of each being in opposition to that of the other, whereby said digger means is adapted to shift dirt excavated from the ditch trench to each side thereof.

9. In the organization set forth in claim 8, including:

deflectors outstanding from each side of the digger means adapted to push a substantial portion of excavated earth away from the trench and out of the path of the vehicle wheels.

10. In the organization set forth in claim 7, including:

a hood enclosing approximately three-fourths of the auger circumference and exposing only the aforesaid leading portion of the under edge of the auger.

11. In the organization set forth in claim 7, wherein:

said digger section includes a base shoe trailing the auger and conforming to the form of the ditch trench to support the hopper and forming means, said base shoe being adapted to drag against and to smooth the walls of the ditch trench prior to the placement of concrete therein.

12. In the organization set forth in claim 11, including:

a peripheral slot about said base shoe; and

a sprinkler means within the slot adapted to wet the surface of the ditch trench as the base shoe portion moves therepast.

13. In a ditch building apparatus adapted to dig a ditch and line the same with concrete, which combines:

a. a vehicle, including a suspension means adapted to move along the course of the ditch;

b. a digger means supported by the suspension means adapted to dig a trench as the vehicle moves along the ditch course and to discharge earth from the trench excavation laterally therefrom;

c. a concrete receiving hopper connected to and trailing the digger to receive and to hold a charge of concrete and to deposit the same into the aforesaid trench; and

d. a forming means connected to and trailing the hopper to dispense concrete from the hopper within the trench as a lining to form a finished ditch, the improvement comprising:

a pocket forming means located behind the digger means, including a transverse guideway means and a ram within the guideway means adapted to be extended laterally therefrom to form a pocket in the earth at the side of the ditch trench;

a notch finishing means near the trailing end of the aforesaid forming means including a transverse guideway means and a ram within the guideway means adapted to be extended laterally therefrom to cut a notch into the concrete ditch lining; and

an indexing means aligned along the course of the ditch, including indicator means at a uniform spacing along the ditch course which is the same, or a simple fraction of, the spacing between the pocket forming means and notch finishing means, and which initiates the extension of the rams of the aforesaid pocket and notch finishing means substantially simultaneously whereby to cause the notch finishing ram to be extended into a pocket previously formed by the pocket ram and filled with concrete after the pocket has moved past the hopper.

14. In the organization set forth in claim 13, wherein:

said indexing means includes a line adapted to be extended along the course of the ditch and the indicator means are lugs carried thereon;

a switch carried on the apparatus having an actuator finger normally touching the line and being actuated by contacting a lug as the apparatus moves along the ditch course; and

means adapted to extend the aforesaid rams responsive to actuation of the switches.

15. In a ditch building apparatus adapted to dig a ditch and line the same with concrete which combines:

a. a vehicle, including a supporting means, a driving means and a steering means having sterrable wheels, adapted to move along the course of the ditch;

b. a digger means supported by the supporting means adapted to dig a trench as the vehicle moves along the ditch course and to discharge earth from the trench excavation laterally therefrom;

c. a concrete receiving hopper connected to and trailing the digger to receive and to hold a charge of concrete and to deposit the same into the aforesaid trench; and

d. a forming means connected to and trailing the hopper to dispense concrete from the hopper within the trench as a lining to form a finished ditch, the improvement comprising:

an automatic alignment means adapted to maintain the alignment of the vehicle along the ditch course, including:

a guide line extended alongside the course of the ditch to parallel the same;

an actuator adapted to shift the steerable wheels to change the direction of the vehicle movement; and

a control means adapted to regulate the actuator having a sensor arm depending therefrom to contact the aforesaid line, said control means being in a neutral position when the vehicle is in proper alignment with the sensor arm being substantially at a vertical position, but being shifted from said neutral position whenever the vehicle moves out of alignment, to thereby compensatively energize the actuator to return the vehicle to proper alignment.

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