United States Patent [19]

Hatcher et al.

[11] **3,779,606**

[45] **Dec. 18, 1973**

[54] **PAVEMENT CUTTING MACHINE WITH IMPROVED LIQUID COOLANT SUPPLY**

[76] Inventors: **Cecil W. Hatcher; Gene Warner,** both of P.O. Box 1263, El Monte, Calif. 91734

[22] Filed: **Aug. 31, 1972**

[21] Appl. No.: **285,256**

Related U.S. Application Data

[62] Division of Ser. No. 119,476, March 1, 1971, Pat. No. 3,703,316.

[52] **U.S. Cl.** **299/39**

[51] **Int. Cl.** **E01c 23/09**

[58] **Field of Search** 299/39–41

[56] **References Cited**

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Primary Examiner—Ernest R. Purser
Attorney—William E. Beatty

[57] **ABSTRACT**

A pavement cutting machine for cutting bumps or grooves. A tractor has a hitch with a cutter trailer and a tank trailer. The tank picks up the sludge from the cutter, filters it and recirculates the filtered water to the cutter. A shroud has a wall around the cutter to provide a vacuum chamber having suction nozzles to pick up the sludge. The nozzles are in the form of upright tubular members having a length sufficient for the lower ends of the nozzles to contact the pavement during operation of the cutter. The cutter and its engine, also the vacuum chamber and nozzles are all carried by a support which is raised or lowered by hydaulic cylinders. The cutter device is a single cutter or two cutters having overlapping shafts at their inner ends with the spacing between adjacent cutting disks the same as on each cutter for cutting grooves or overlapped for cutting bumps.

5 Claims, 29 Drawing Figures

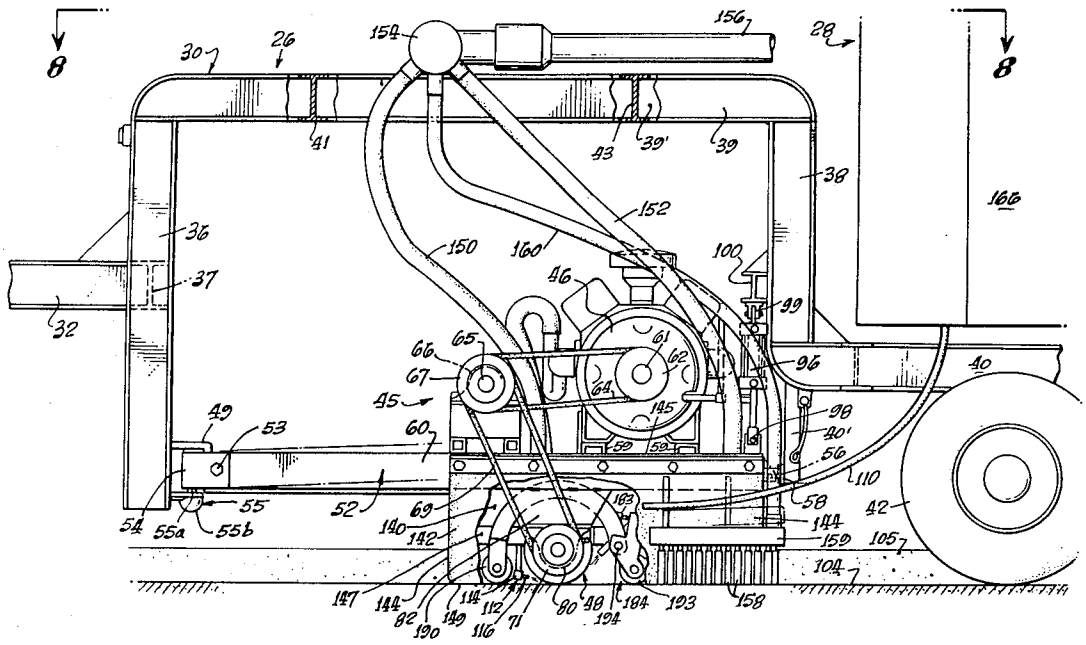


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.

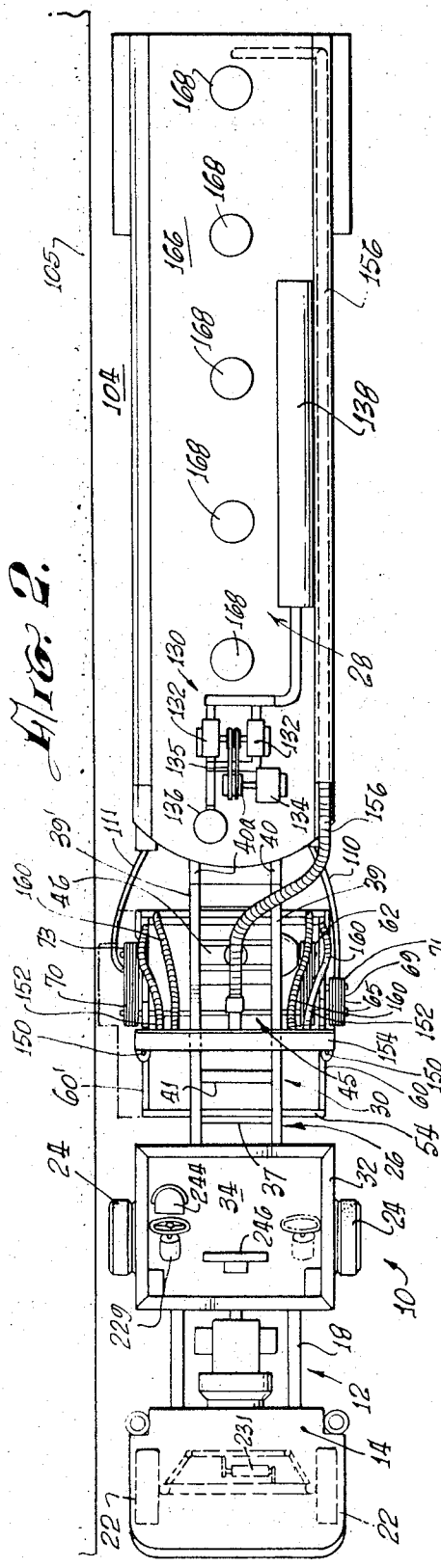


Fig. 2

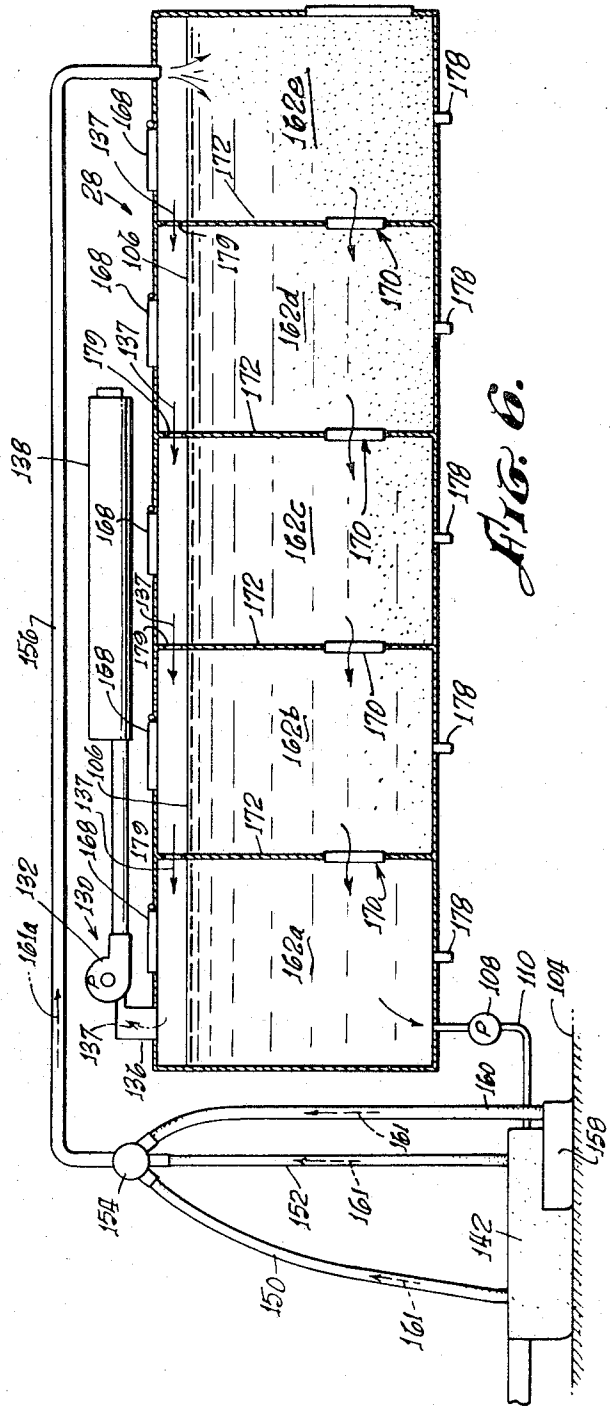


Fig. 4

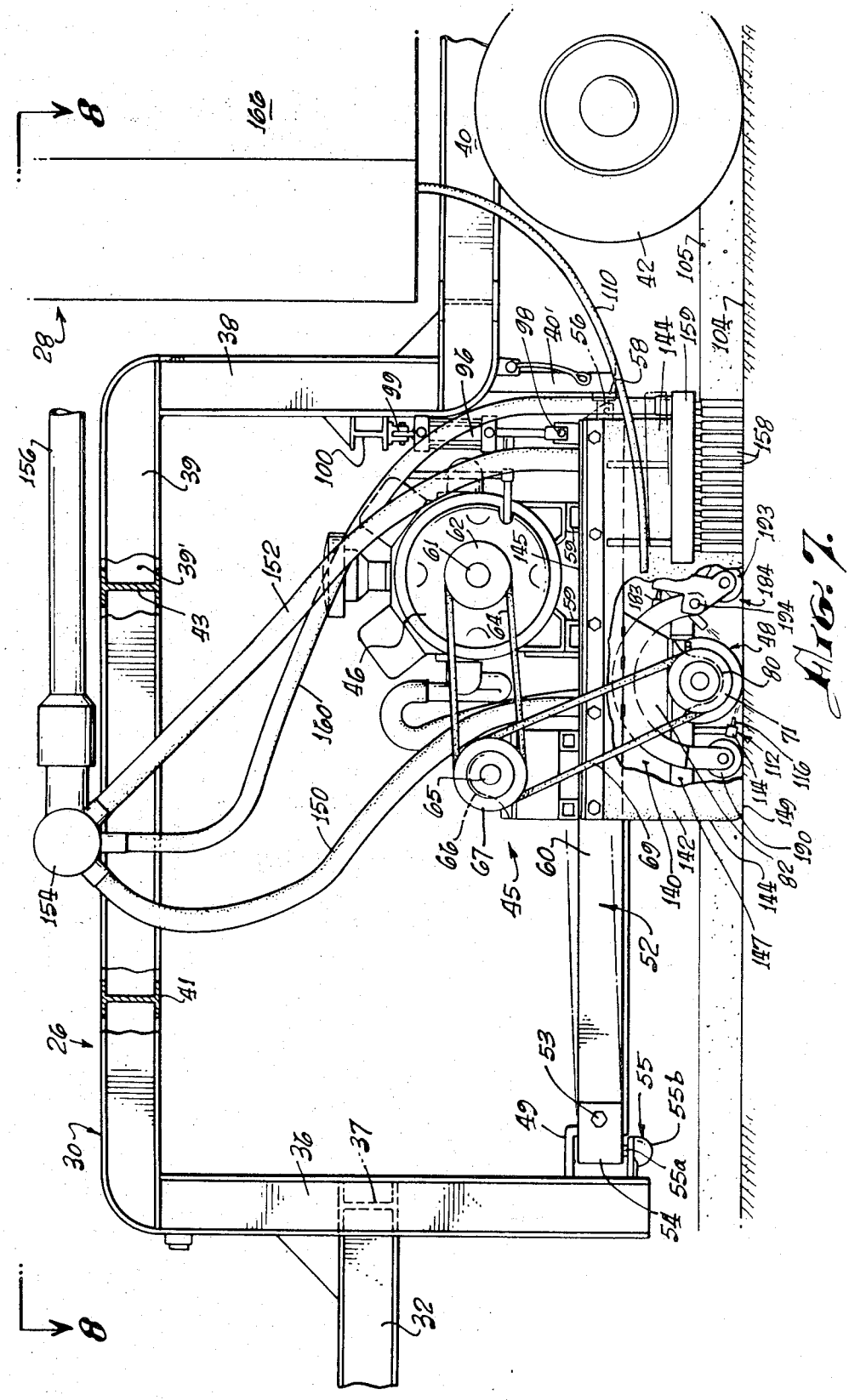

8
166
40
42
105
110
28
38
98
40'
56
58
144
150
104
96
99
100
156
39
158
39'
152
43
62
61
145
163
164
46
64
160
65
66
67
45
60
150
154
69
140
142
52
41
26
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53
55
55b
49
36
37
55a
54
32
8

Fig. 1

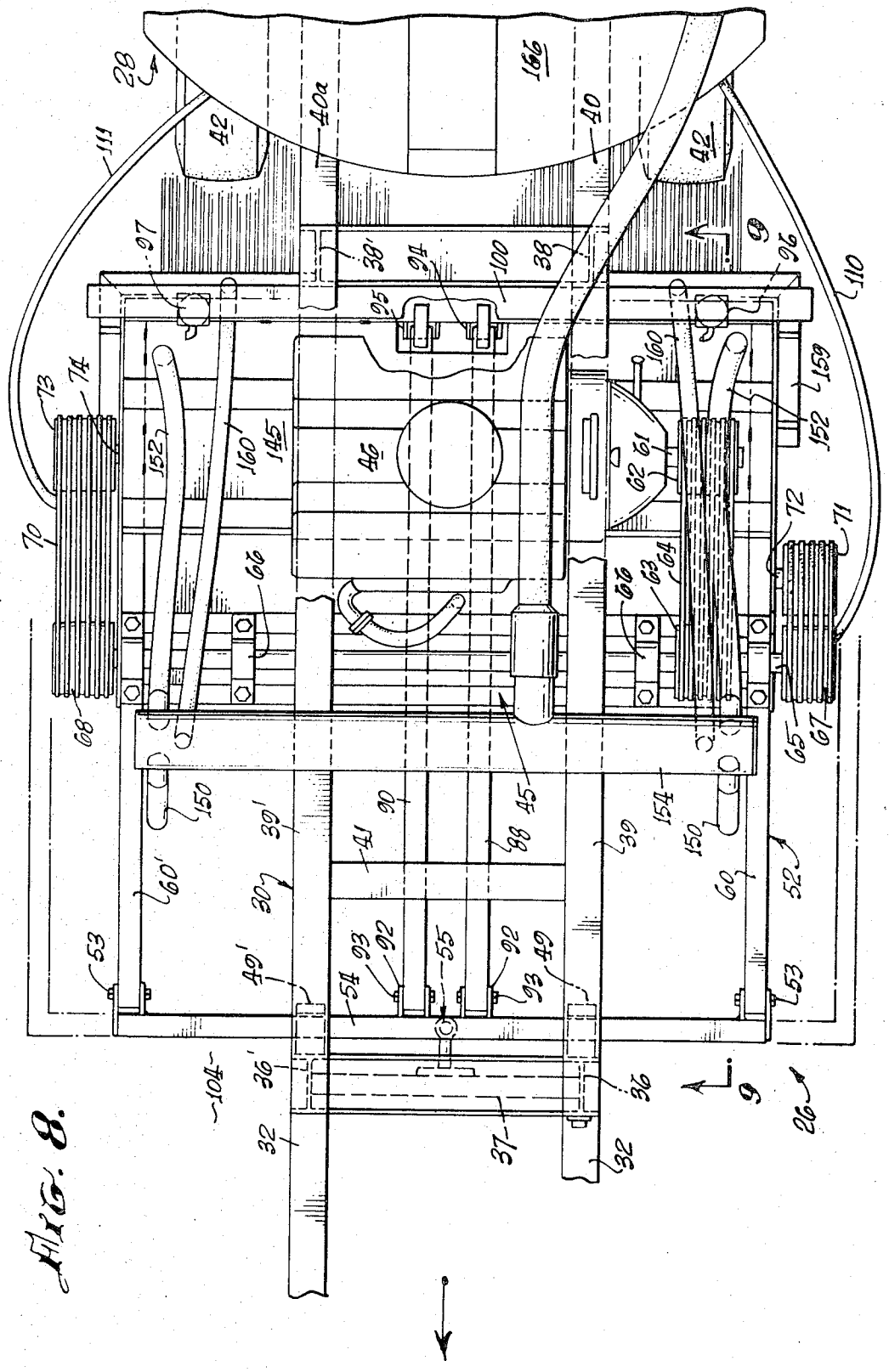


Fig. 8.

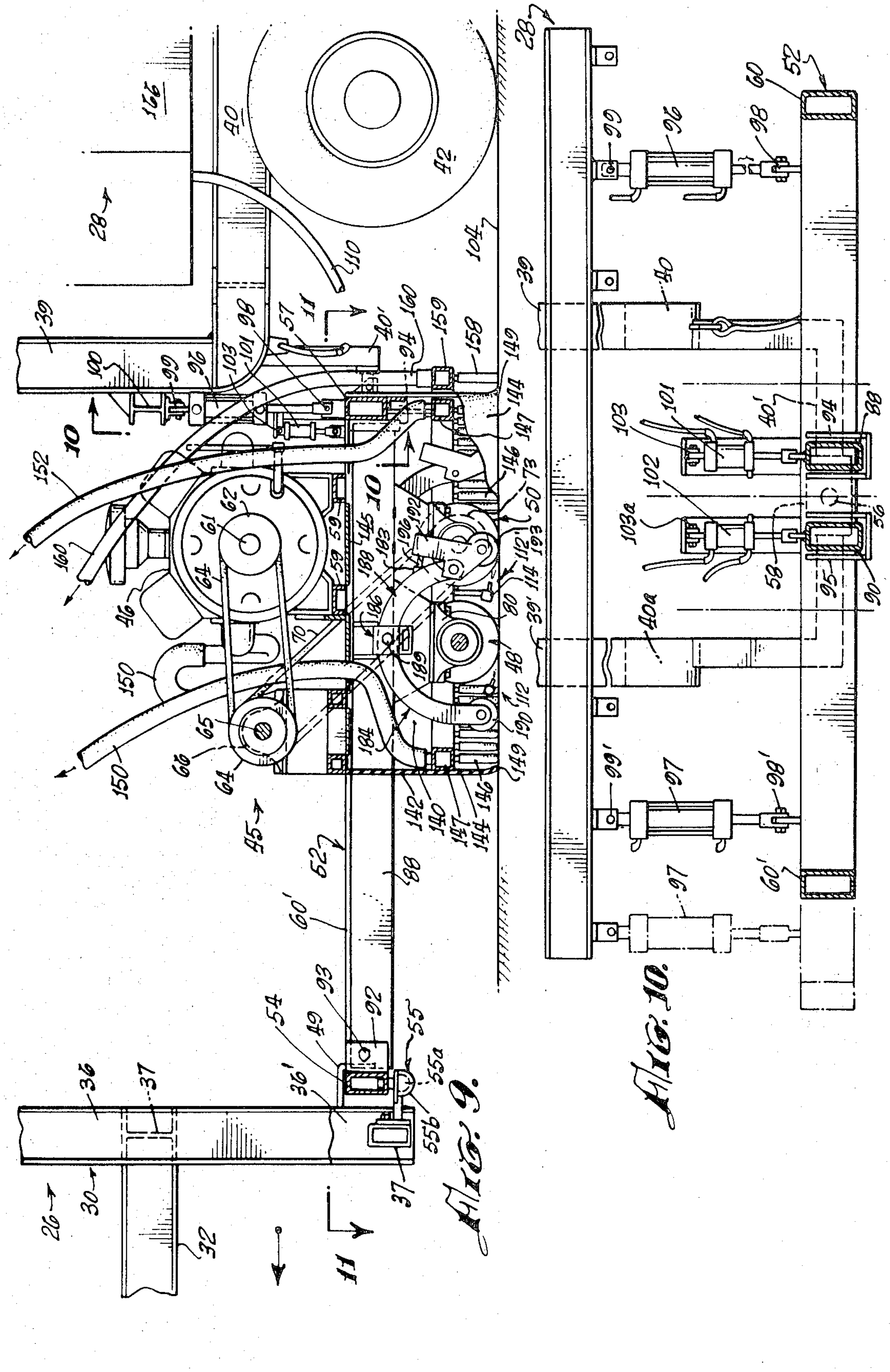


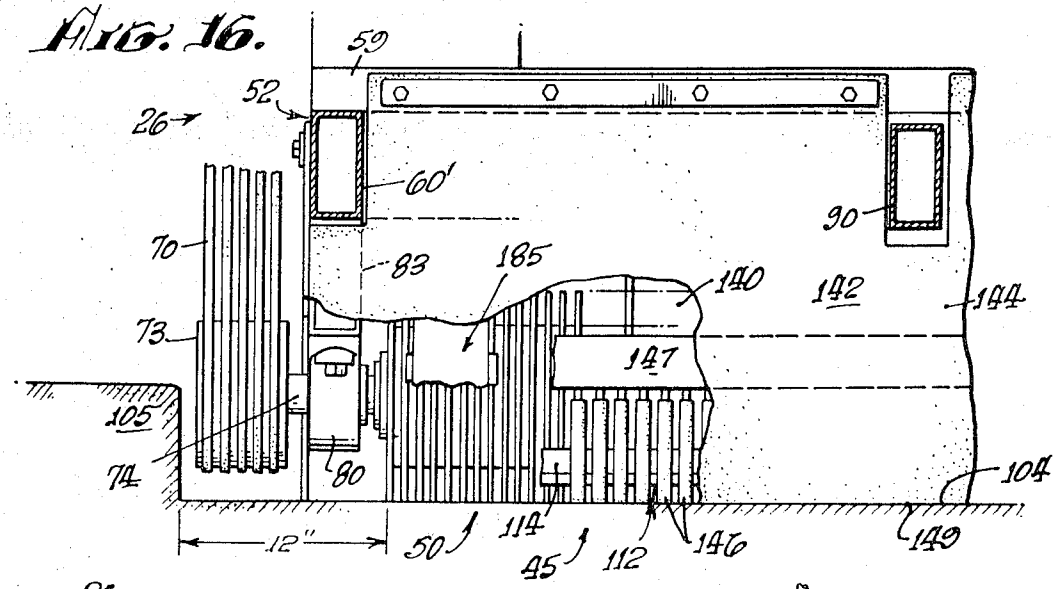
FIG. 9.

FIG. 10.

Fig. 15.

Fig. 14.

Fig. 16.



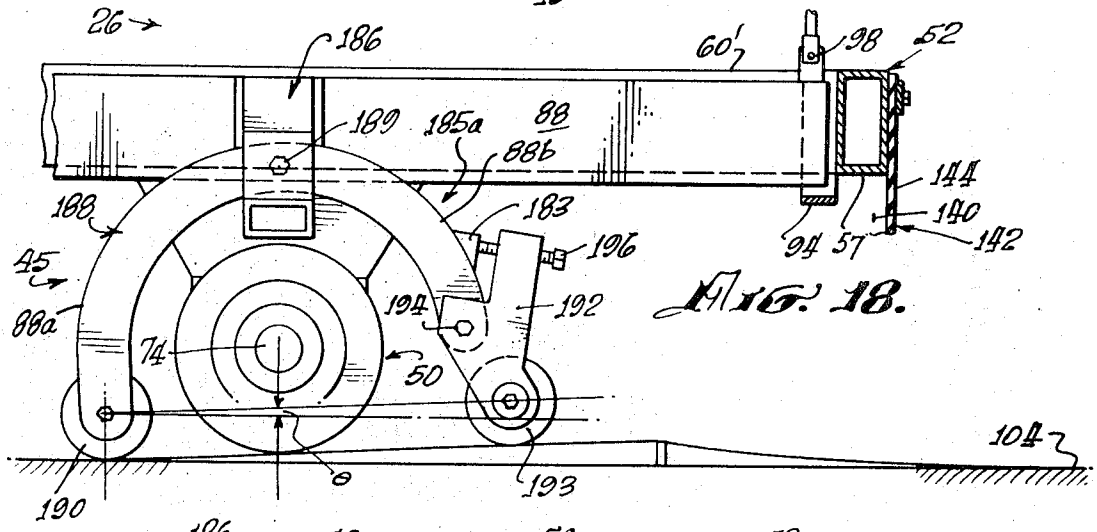


Fig. 18.

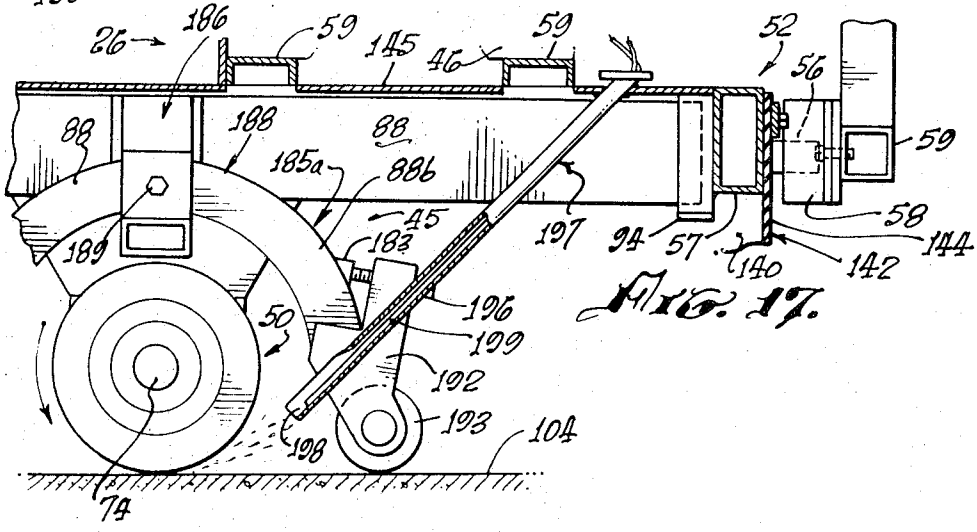


Fig. 17.

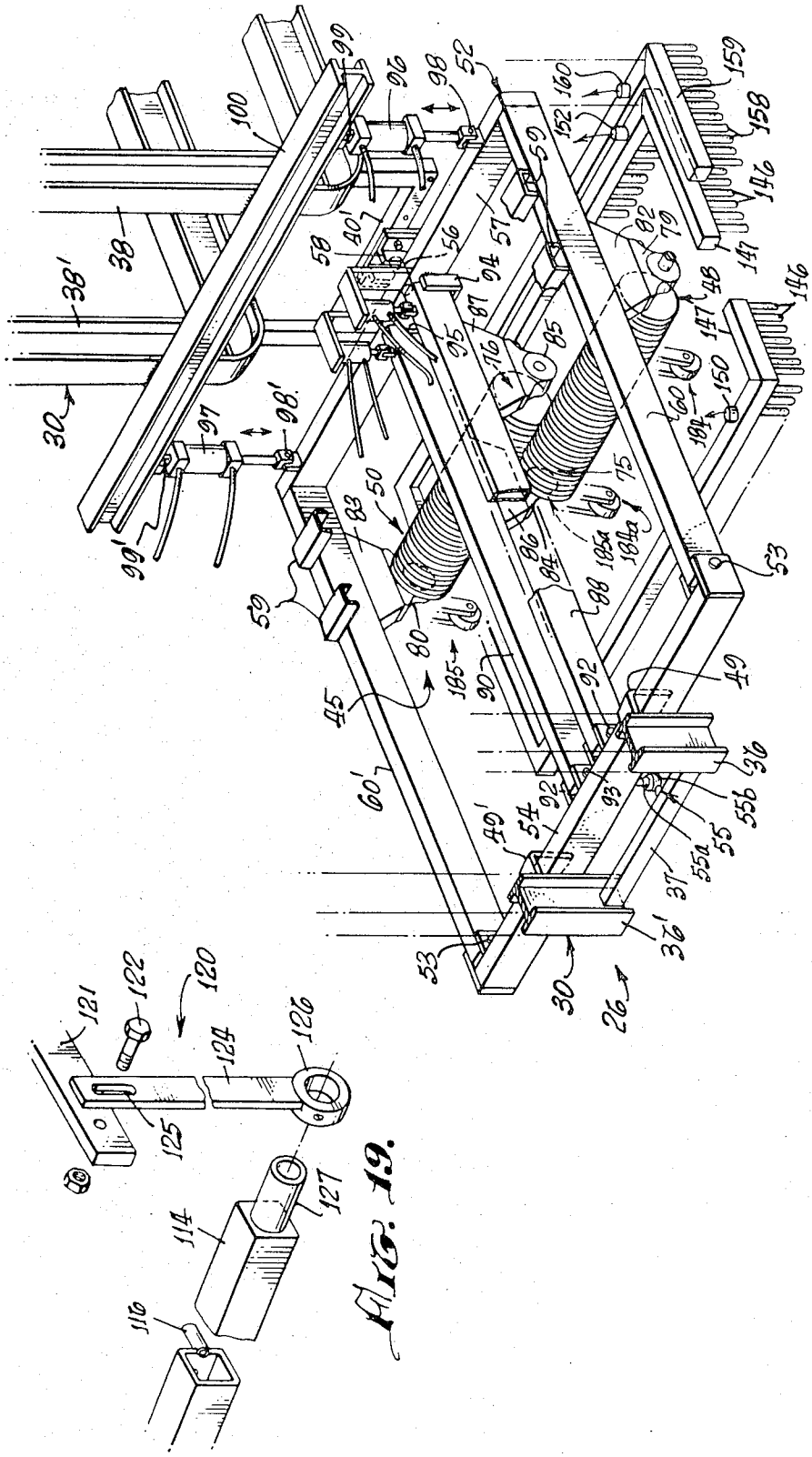


FIG. 20.

FIG. 19.

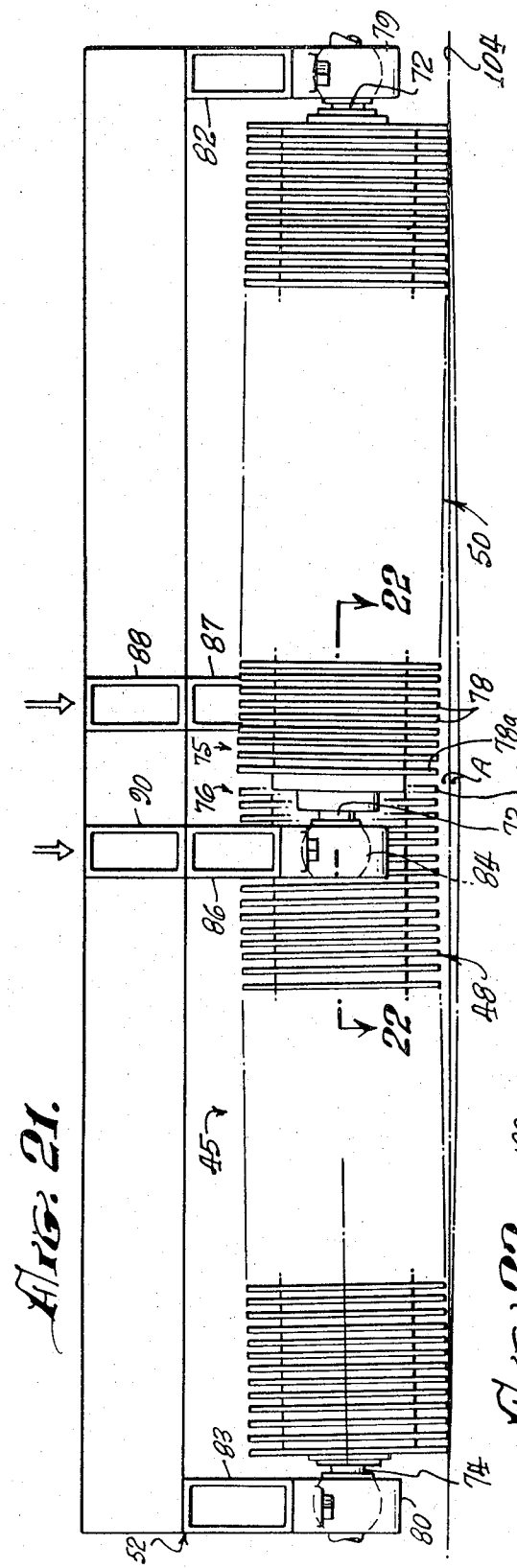


Fig. 21.

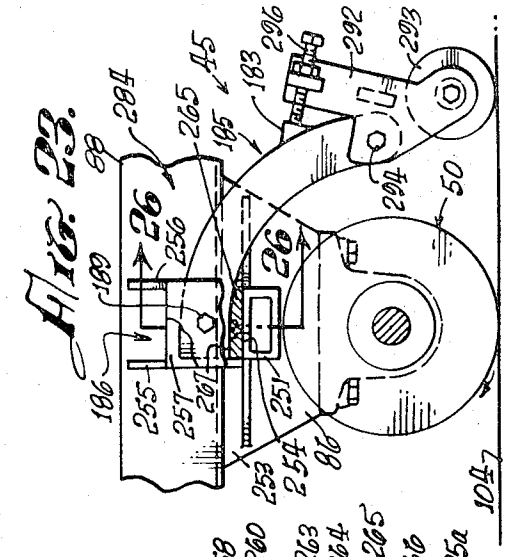


Fig. 23.

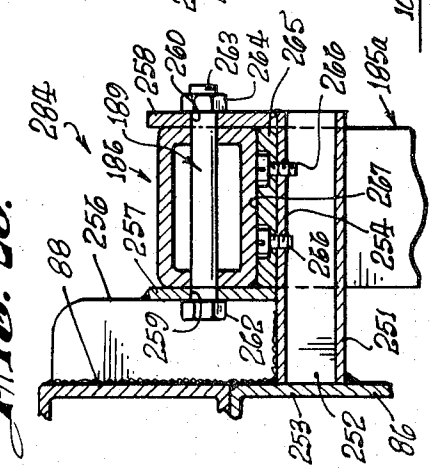


Fig. 26.

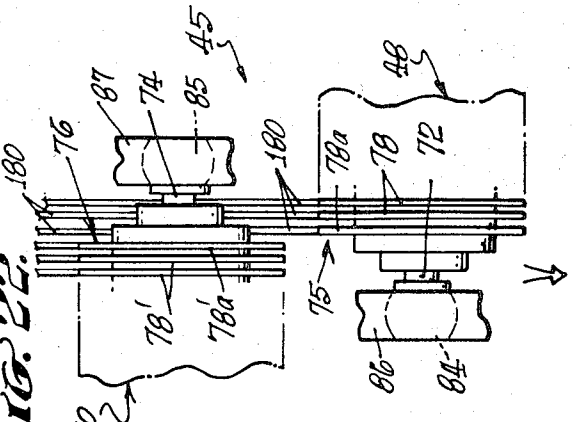


Fig. 22.

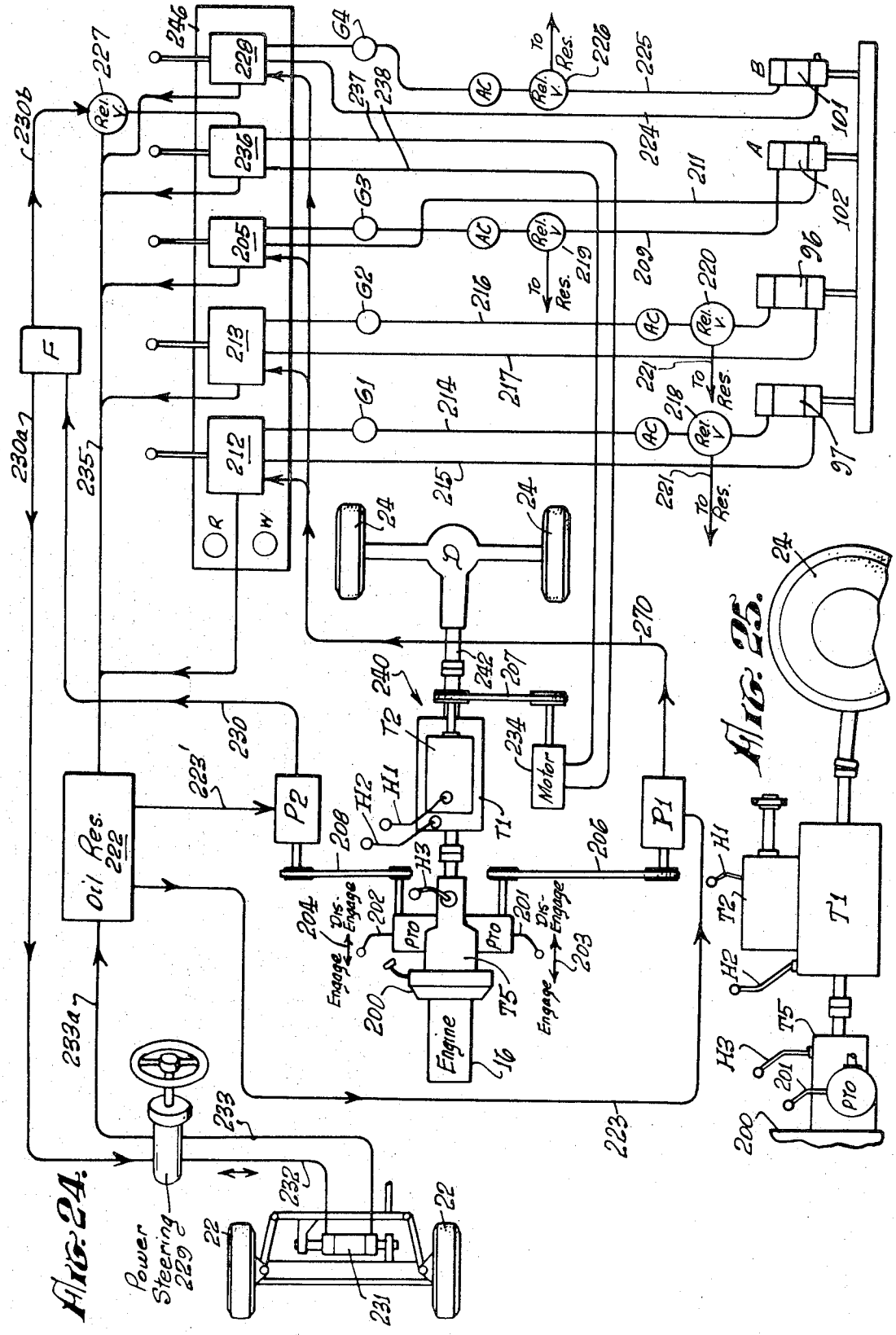

Oil Res. 222
P2
P1
Motor
Engine 16
T1
T2
T5
PTO
Pro
Dis-Engage
Engage
Power Steering 229
F
Rel. V.
AC
To Res.
A
B
R
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D
Res.

FIG. 24.

FIG. 25.

FIG. 27.

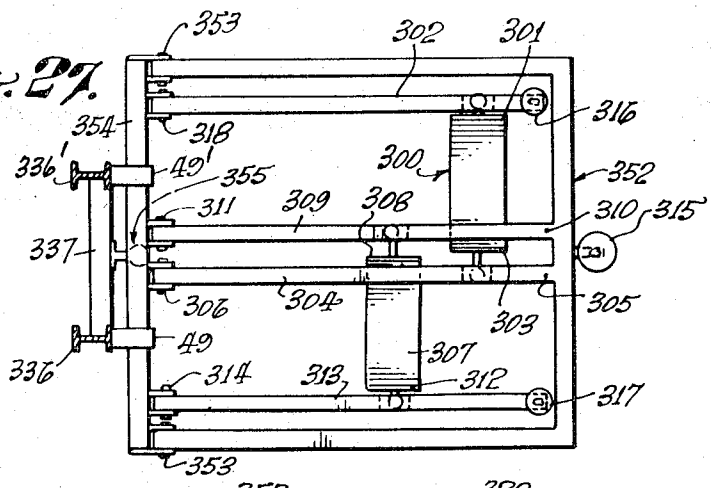


FIG. 28.

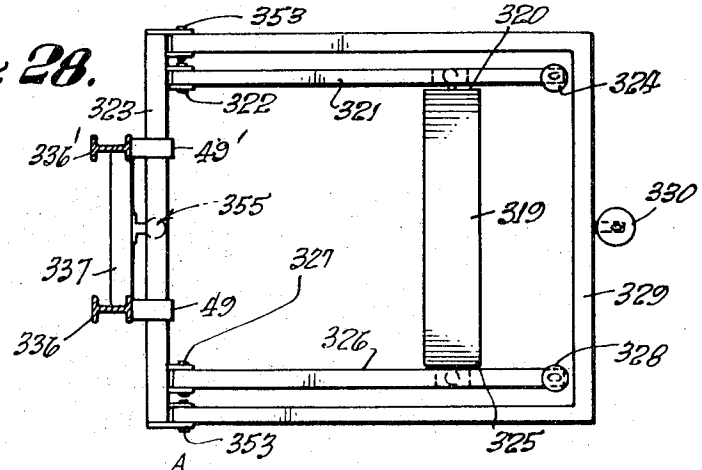
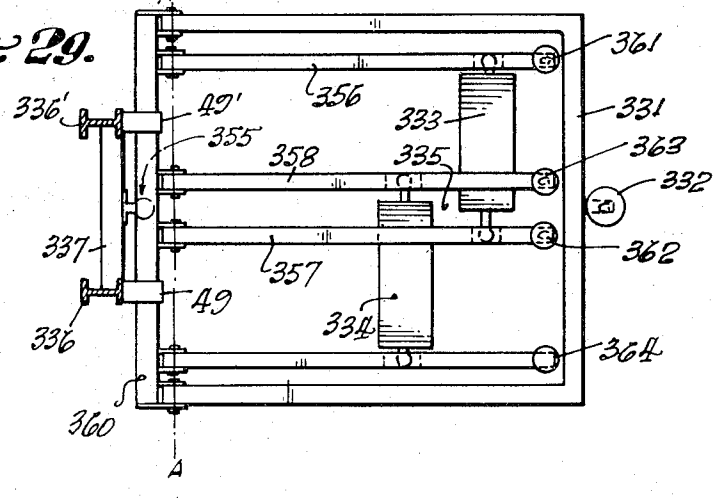


FIG. 29.



PAVEMENT CUTTING MACHINE WITH IMPROVED LIQUID COOLANT SUPPLY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a division of Ser. No. 119,476, filed Mar. 1, 1971 and now U.S. Pat. No. 3,703,316, filed on 11/21/72.

PAVEMENT CUTTING MACHINE WITH TRACTOR TRAILER ASSEMBLY, Ser. No. 278079, filed Aug. 4, 1972 by Cecil W. Hatcher et al.

PAVEMENT CUTTING MACHINE WITH SELECTED DRIVE SYSTEM, Ser. No. 281,952 filed 8/18/72 by Cecil W. Hatcher et al.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a pavement leveling or grooving machine having a vehicle having a pavement cutter wherein a tractor pulls the cutter vehicle and a water tanker recirculating water to cool the cutter disks.

2. Description of the Prior Art

As is well known in the art, there are various machines used for grooving or leveling road surfaces. However, each of the known devices have limitations, and problems associated with them. One problem is the transporting of the machines from one operation site to another and, after reaching the site, being able to operate under ideal conditions to properly complete the work required. Another area where the present machines are lacking is the capabilities of keeping the required depth of the grooves as the cutter assembly, or assemblies, make their pass over a road bed having an uneven surface. It is also necessary to have a machine that is not only capable of grooving the road surface but, in addition, serving a dual purpose as a leveling apparatus.

A series of diamond blades or disks are generally used for the leveling and grinding of the grooves, these blades being very expensive and, if not properly protected from overheating, each can be damaged and become ineffective during its working operation. It is, therefore, necessary to supply a cooling system that will operate as long as needed while the blades are in operation. The cooling system is generally a liberal supply of water sprayed along the cutting edge of each blade as it rotates during a cutting or grinding operation. Apparatus is provided to continuously supply water to the cutting area during the complete cutting cycle having an extreme length of highway surface to be worked.

SUMMARY OF THE INVENTION

The invention comprises a dual tandem apparatus for leveling or grooving roads and highway surfaces, whereby cars and the like will be substantially protected from skidding, especially in wet weather. The dual tandem apparatus comprises a tractor having a cab section for transporting the entire machine down the highway to a work location, a first trailer section positioned intermediate the tractor and a second trailer section. The first trailer section is operably connected to the tractor as a pavement leveling and grooving machine, and the second and end trailer is a tanker for supplying a liquid coolant, such as water, to the grooving and leveling apparatus. The tractor section is adapted with the equipment and controlling apparatus

to operate the movement of the entire vehicle while traveling down the highway to a work location by use of a direct drive to its rear-wheel drive at moderately high speeds with its total complement of trailers. If the Diesel engine in the tractor were to operate at low gear and drive the equipment at a slow speed, the engine's powerful direct drive would damage parts related to the grooving apparatus, if the parts met an obstruction. Hence, a hydraulic drive from the Diesel engine is provided to operate the entire system of the tandem trailer unit when the engine clutch is operated to disconnect the transmission from the traction wheels and engage a power take-off, to supply the hydraulic drive to operate the vehicle and its systems.

The leveling and grooving machine trailer section comprises either one or two rotary cutter units. If two are used, one of the units is supported in advance of the other, with their cutter shafts overlapping at their inner ends. Each assembly includes a plurality of cutting disks, or blades, separated by a certain spacing, depending on the use of the machine as a leveling or grooving device, the same spacing being preserved at the inner ends of the two cutter units. A somewhat U-shaped movable frame is pivoted at its front end on a horizontal axis. The outer end of each unit is supported either by the frame or by a floating beam carried by the frame, and the same applies to the inner end of each unit. Hydraulic cylinders are provided for raising and lowering the frame, and an additional hydraulic cylinder is provided for each of the floating beams. If two cutters are used, they can be adjusted to substantially fit either the convexity or the concavity of the pavement. three-fourths

A liquid coolant is supplied for the cutters from the tanker by means of a pumping system. The water is recirculated from the cutting area in the form of sludge back to the tanker by means of a vacuum apparatus. Said liquid is sprayed through jet nozzles adjacent the cutting blades and then is returned by suction nozzles positioned about the cutting units. The nozzles are in the form of upright tubular members having a length sufficient for the lower ends of the nozzles to contact the pavement during operation of the cutter. There is also provided a shroud to cover the lower portion of the grooving apparatus, which enhances the vacuum operation by reducing the fluid pressure within the tank.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring more particularly to the accompanying drawings, which are for illustrative purposes only:

FIG. 1 is a side-elevational view of the invention showing a tractor pulling a cutter trailer and a water tank trailer.

FIG. 2 is a top plan view of FIG. 1.

FIG. 3 is a sectional view taken on line 3—3 of FIG. 1.

FIG. 4 is a sectional view taken on line 4—4 of FIG. 3.

FIG. 5 is a fragmentary perspective view of a filter unit as seen in FIG. 3.

FIG. 6 is a schematical cross-sectional view of the tank trailer and the vacuum system.

FIG. 7 is an enlarged side view of the grooving trailer with portions broken away for clearer illustration thereof.

FIG. 8 is a top plan view of FIG. 7 on line 8—8 thereof.

FIG. 9 is a cross-sectional view taken on line 9—9 of FIG. 8.

FIG. 10 is a cross-sectional view taken on line 10—10 of FIG. 9.

FIG. 11 is a cross-sectional view taken substantially on line 11—11 of FIG. 9 thereof.

FIG. 12 is an enlarged sectional view taken on line 12—12 of FIG. 11.

FIG. 13 is an enlarged sectional view taken on line 13—13 of FIG. 12 showing the cutter blades cutting grooves in a road surface.

FIG. 14 is an enlarged sectional view taken substantially on line 14—14 of FIG. 11.

FIG. 15 is a sectional view taken substantially on line 15—15 of FIG. 14.

FIG. 16 is an enlarged plan view of a portion of the grooving trailer positioned adjacent a curbing of a road surface.

FIG. 17 is a sectional view taken substantially on line 17—17 of FIG. 11 thereof.

FIG. 18 is a view illustrating the depth control wheel assembly for adjusting the depth of cut of the blades of the cutting assembly for cutting grooves.

FIG. 19 is an exploded perspective view of a supporting bracket of a water nozzle spray unit.

FIG. 20 is a partial perspective view of the grooving trailer assembly.

FIG. 21 is a sectional view illustrating the cutting assemblies supported in a somewhat universal mounting and positioned for cutting an irregular road surface.

FIG. 22 is a partial top plan view of the cutting assemblies with their inner ends adjacent each other.

FIG. 23 is a sectional view of a modified form of depth control for the cutting assembly adapted for cutting bumps.

FIG. 24 is a flow diagram of the hydraulic system for controlling the over-all operation of the leveling or grooving machine.

FIG. 25 is a schematic view of the transmission and power take-off shown in FIG. 24.

FIG. 26 is an enlarged fragmentary sectional view on line 26—26 of FIG. 23.

FIGS. 27, 28 and 29 are schematic views of modifications of the frame and floating beam support for the cutter or cutters.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to the drawings, there is shown in FIG. 1 a tractor-trailer vehicle, generally indicated at 10, comprising a tractor, indicated generally at 12, which is provided with a typical cab 14 and a Diesel or similar engine 16 mounted at the front end of the tractor frame 18. The frame 18 is provided with a swivel bed or hitch 20 for an operable connection between the tractor and a tandem trailer. Tractor 12 is movably supported by a set of front wheels 22 for steering the vehicle 10 and a back set of drive wheels 24 as generally found in such a vehicle.

However, there is included means for disengaging the engine power from the rear drive or traction wheels 24 to engage a hydraulic drive system when required. A more detailed description of said means will be described hereinafter.

There is operably connected to the swivel bed or hitch 20 of the tractor 12 a first tandem trailer unit 26 and a second tandem trailer unit 28 which is operably connected to said first trailer unit 26 by a swivel bed or hitch 29, supported on the rear of said first trailer unit. The first trailer unit 26 includes a leveling or grooving machine having a rotary cutter assembly 45, having a hitch 55 with the frame structure 30 which in turn has a hitch 20 with the tractor 12.

The trailer unit 26 comprises a carriage or frame structure 30 having a somewhat Z-shaped configuration which includes a horizontal box framework 32 having a mating member 33 for the swivel bed 20 and a platform 34, as seen in FIG. 2. Positioned rearwardly of said platform 34 and attached to frame 32 are a pair of parallel vertical beams 36, 36' spaced apart sufficiently to receive a transverse support bar 37, as seen in FIGS. 11 and 20. The beams 36, 36' are secured to the box frame 32 intermediate their ends. Rearwardly disposed from said beams 36, 36' is a second pair of matching beams 38, 38', said beams 36 and 38 being interconnected by overhead horizontal girder member 39, and beams 36' and 38' being similarly interconnected by an overhead horizontal girder member 39'. The girders 39, 39' have suitable transverse supports shown as I-beams 41 and 43, see FIGS. 2 and 7, welded at their ends into the girders 39, 39'. Attached to the lower portion of the rear vertical beams 38, 38' is a set of parallel frame members 40, 40*a* (FIGS. 8 and 20) having a platform to support the second swivel bed or hitch member 29 (FIG. 1). To carry the rear portion of the frame structure 30, there is provided a set of tandem wheels 42 positioned directly under the swivel bed member 29 whereby the front end of the second trailer 28 is operably connected thereto. The trailer 28 has rear wheels 165.

Referring more particularly now to FIGS. 7, 8, 9 and 11, in which a more detailed construction of the frame structure 30 is shown, there is provided a rotary cutter asembly, generally indicated at 45, operably mounted within the frame structure 30 of the carriage, said cutter assembly 45 comprising an independent drive engine 46 for operating a pair of rotary cutter units, indicated generally at 48 and 50, respectively. There is also provided means for supporting one of said cutting units in advance of the other, with the inner ends of said cutter units in substantial alignment. The supporting means comprises a U-shaped frame structure 52, as seen in FIGS. 8, 11 and 20, hingedly connected, as indicated at 53, at its forward open end to a header 54, said header 54 having a hitch 55 which includes an upper ball member 55a secured to the header 54 and a cooperating lower mating socket member 55b horizontally projecting from and secured to the transverse support bar 37. Oppositely and rearwardly disposed from the header 54 is the bight portion 57 of the U-shaped frame 52, said bight 57 being a rear transverse member having mounted thereon a slide 56 in the form of a cylindrical pin which is rotatably received in and guided for vertical and pivotal movement by vertical spaced angle irons providing slot means 58 carried by bracket 40' depending from frame members 40, 40*a*, see FIG. 20. The slot means 58 prevents lateral movement of said frame 52 with respect to the frame structure 30, while permitting rocking movement about a horizontal axis.

The beams 36, 36', see FIG. 20, have an angle bracket 49, 49', respectively, extending over the header 54 at opposite sides of its longitudinal axis to limit pivotal movement of header 54 about that axis,

particularly when acted on by hydraulic cylinders **96** and **97**, described later.

Due to the ball and socket hitch **55** at one end of the frame **52** and the slide **56** rotatably received in slot **58**, the frame and cutter assembly **45** together are capable of being angularly adjustable about a horizontal axis *a* –*a*, seen in FIG. **11**, said hitch and said slide permitting said cutter units to be readily adapted to an inclined surface, when required.

An independent engine **46** is used to impart the rotary movement necessary to operate the cutter units **48** and **50**, said engine being mounted to the floating U-shaped frame **52** adjacent the bight portion **57** of the U by transverse channel members **59** secured at their ends to the side members **60, 60'** of the frame **52**. The power output shaft **61** of the engine **46** is provided with a plurality of pulleys **62** operably connected to pulleys **63** by belt **64**, said pulleys **63** being securely disposed adjacent one end of a transverse shaft **65** which is rotatably supported in bearings **66**. Disposed on the outer free ends of the shaft **65** are a plurality of additional pulleys **67** and **68**, respectively. Said pulleys **67** and **68** are operably interconnected to cutter units **48** and **50** by drive belts **69** and **70**, respectively. As shown in FIG. **7**, belts **69** loop over the upper pulleys **67** to a set of lower pulleys **71** which are attached to a rotary shaft **72** of the cutter unit **48** adjacent one side of the frame **52**. As shown in FIG. **8**, the upper pulleys **68** are oppositely disposed from pulleys **67** on shaft **65** and interconnected to a lower set of pulleys **73** secured to a rotary shaft **74** of the cutter unit **50**.

As mentioned above, the cutter units **48** and **50** are so arranged that one assembly is positioned forwardly of the other cutter assembly with the endmost disks **78***a*, **78'***a* of their inner ends **75** and **76** spaced apart the same distance as the spacing between adjacent disks (FIG. **22**). Each cutter unit **48** and **50** comprises a plurality of evenly spaced-apart cutter disks **78, 78'** having identical diameters and secured on the shafts **72** and **74** for rotation therewith. The disks are generally provided with diamond bits for cutting hard materials, such as cement and concrete.

In FIGS. **15, 20, 21** and **22**, the shafts **72** and **74** are shown journaled at their outer ends by universal bearings **79** and **80**, respectively, said bearings being supported within dual pillow blocks **82** and **83** along the rearward section of the side members **60, 60'** of the frame **52**. However, the inner ends **75** and **76** of cutter units **48** and **50**, respectively, have their shafts **72** and **74** journaled in bearings **84** and **85**, respectively, supported within dual blocks **86** and **87**, respectively.

As shown in FIGS. **11** and **20**, a pair of parallel floating beams **88** and **90** are provided along the inner longitudinal length of the frame **52** for supporting the inner ends of each cutter unit. Each floating beam **88** and **90** is independently hinged to the header **54** by brackets **92** and bolts **93**, acting as hinge pins, at the forward end thereof. As shown in FIGS. **8, 11** and **20**, the opposite or rear free end of each beam **88** and **90** is movably received within the U-shaped brackets **94** and **95**, respectively. Said brackets are secured to the rear bight portion **57** of the frame member **52**. It should be particularly noted that each beam is capable of being actuated individually with respect to each other, as well as with respect to the floating frame **52**.

As shown in FIG. **20**, the inner support block **86** for the inner end of shaft **72** is mounted on beam **90**, whereas the block **87** for the inner end of shaft **74** is carried by beam **88**, with the inner ends of those shafts in overlapping relation as also shown in FIG. **22**. This construction makes it possible to preserve between the endmost disk **78***a* of the cutter assembly **48** and the adjacent endmost disk **78'***a* of the cutter assembly **50**, at the inner ends of those cutters, for groove cutting purposes, a spacing which is substantially the same as the spacing between the adjacent disks on each cutter assembly, as indicated at **180** which represents the uniform spacing of kerfs or grooves in the pavement resulting from the cutting action of the innermost disks of both assemblies. For bump cutting purposes, the inner ends of the cutters may overlap as shown in FIG. **29**.

As shown in FIGS. **10** and **20**, the frame **52** and the rotary cutting assembly **45** are lifted or lowered by means of a pair of hydraulic cylinders **96** and **97** which are hingedly connected at their lower ends **98** and **98'** to the rear end of frame **52**, and their upper ends **99** and **99'** are hingedly connected to the underside of a transverse-extending beam **100** which is secured to the rear vertical beams **38, 38'** of the frame structure **30**. The bight or rear end **57** of frame **52** with the cutter assemblies **48** and **50** pivots about a horizontal axis passing through the hinge **53** and the hinge pins **93** of the beams **88** and **90**. Since the tank trailer **28** is loaded with a dead weight of a large quantity of water, the frame structure **30** and the upper ends of cylinders **96** and **97** are held down from any vertical movement thereof when the cylinders **96** and **97** are activated, when the cutter assemblies **48** and **50** are in working engagement with the pavement. The force of the cylinders **96, 97** butt against the over-all weight of the tank which becomes an effective opposing force against the lifting effort of the cylinders **96** and **97**. Not only can the frame **52** be adjusted vertically, but it can also be tilted at an angle through the longitudinal axis a-a (FIG. **11**) by adjusting the hydraulic cylinders **96, 97**.

There is hingedly connected at the free or rear ends of beams **88, 90** hydraulic cylinders **101** and **102**, respectively, for operating the rear end of each floating beam in different or similar vertical displacements. The hydraulic cylinders **101** and **102** are hingedly supported above the adjacent floating beams **88** and **90**, respectively, by upside-down L-shaped brackets **103** and **103a** which are fixedly secured to the rear **57** of the floating frame **52**.

FIG. **21** shows an example of how the inner ends of the cutter units **48** and **50** can be positioned at a greater elevation than their outer ends to fit a convex road surface. The inner ends can also be adjusted lower than the outer ends to fit a concave road surface. Therefore, by adjusting the floating beams **88** and **90**, the inner ends of said cutters may be raised or lowered with respect to their outer ends to substantially fit either a convexity or a concavity, as indicated at A in the pavement **104**.

When it is desired to move to a different location and travel at comparatively high speed with the cutter assemblies **48** and **50** in elevated position, the cylinders **96** and **97** are operated to raise the rear end **57** of frame **52**, and in so doing, the outer ends of the cutter assemblies are raised, their inner ends and the floating beams **88** and **90** being raised by reason of the brackets **94, 95**, see FIG. **10**. The brackets **94, 95** are carried by the frame member **57** and underhang the beams **88** and

90 to lift them when the rear end 57 of the frame is lifted. Brackets 94 and 95 are open at their tops to permit the upward movement of the beams 88 and 90 under working conditions, the brackets 94 and 95 then being in a lowered position free from supporting relation with the beams 88 and 90 which are then floated. The operator can adjust the pressure on the cylinders 101 and 102 to adjust the beams 88 and 90 and the inner ends of the cutter assemblies so as to suit working conditions and obtain a uniform depth of groove with resulting maximum length of life of the cutter disks.

As shown in FIGS. 1 to 6, 14 and 15, the rotary cutter assembly 45 is provided with a continuous flow of liquid coolant 106 which consists, generally, of water supplied from cell 2of tank 44 of the end trailer 28. This water coolant is pumped by a pumping means 108 which is located at the front end of the tank 44 and is provided with a pair of flexible conduits, or hoses, 110 and 111 interconnected to separate spray nozzle means, indicated generally at 112 and 112'. In FIG. 15 there can be seen the hoses 110 and 111 attached to the lower portion of side member 60 of the frame 52 and oppositely arranged in like manner, each of which is operably connected to individual spray nozzle means 112 and 112'. The nozzle means 112 and 112' are identical and both comprise a tubular conduit or manifold 114 having a plurality of spray nozzles 116, see FIG. 19, spaced along the side of the conduit facing the cutting edge of the blades 78, 78' as they contact the pavement during cutting and grinding thereof, thereby spraying water for coating the blades or disks of the cutting units 48 and 50, respectively. As better seen in FIG. 14, a nozzle spray means for each cutter or grinder unit is attached at the free closed ends by brackets 118 and at the opposite ends by an adjustable bracket assembly, generally indicated at 120. The bracket assembly 120 is more clearly illustrated in FIG. 19, in which there is shown a spacer bar 121, which is secured to the inner lower portion of the side member 60 of the frame 52 by bolt 122. Also secured by bolt 122 is an adjustable arm 124 having one end provided with a slot 125 and the other end provided with a bearing 126. Said bearing 126 is adapted to receive a communicating neck member 127 of the conduit 114, which when mounted in said bearing is operably coupled to the hoses 110 and 111, not shown, whereby water from tank 44 can be pumped to the cutting blades.

In order to supply a continuous, uninterrupted flow of water to the blades 78, 78', there is provided a vacuum system, generally indicated at 130 in FIGS. 1, 2 and 6. This system is used to return the water, along with the sludge material created by the cutting or grinding of the pavement, to the tank 44. The vacuum system comprises a vacuum pump 132 mounted to the end tank trailer 28. This pump is operated by motor 134 by means of drive belt 135, as seen in FIGS. 1, 2 and 6. A vacuum is pulled from within the tank 44 through an outlet passage 136 located in the front upper wall of the tank cell 162*a*. The vacuum flow is indicated by arrows 137 from the tank 44 through passage 136 into pumps 132 where it is pumped to atmosphere through a manifold 138. As the pressure within the tank 44 is reduced by the vacuum system 130, a flow of water and sludge is created between the cutting assembly 45 and tank 44. This flow is accomplished by establishing a vacuum chamber 140 which is defined by a flexible and elastic shroud, indicated generally at 142, having a somewhat rectangular wall or curtain 144 secured to and depending from frame 52. Said chamber also includes an upper shield partition 145, see FIG. 14, to seal or close the top of the vacuum chamber 140. The lower edges 149 of the side walls 144 of the vacuum chamber 140 form a sealing contact with the pavement around the cutting units and the spray nozzles. Included within the vacuum chamber 140 is a plurality of suction nozzles 146 which are operably connected to a rectangular manifold 147 connected to conduits like 150, 152 and 160 in FIG. 6 which lead to said tank 44 for returning the water and sludge to said tank. The suction nozzles are in the form of upright tubular members having upper ends connected to a manifold 154 and having a length sufficient for the lower ends of the nozzles to contact the pavement during operation of the cutter as shown in FIGS. 7, 9, and 14.

Referring to FIGS. 9, 14 and 20, the suction nozzles 146 are attached and depend downwardly from a rectangular tubular manifold 147. The manifold 147 is adapted to receive conduits 150 and 152, see FIG. 9, which lead to an overhead junction manifold 154, see FIGS. 2 and 6, said manifold 154 having a single input connection to the tank 44 through pipe 156, which is received in the upper rear portion of said tank to complete the return flow of the coolant and sludge to said tank. As shown in FIG. 14, a back-up group of suction nozzles 158 may be employed to recover leakage about the trailing shroud. This additional group of nozzles is supported by a tubular frame 159 acting as a manifold, also connected to the manifold 154 by a conduit 160 for return flow through pipe 156.

The schematic view of FIG. 6 shows the vacuum system with the shroud 142 in sealing contact with pavement 104, followed by nozzles 158. The arrows 161 show the return flow of the coolant through the conduits 150, 152 and 160, then into manifold 154, and again arrow 161a showing flow through pipe 156 into the rear section of the tank 44 in the area having a low pressure which is created by the vacuum system 130.

In order to accommodate an uninterrupted flow of water from the end trailer unit 28, its tank 44 has a plurality of sections, or cells, 162*a* to 162*e* capable of holding large quantities of coolant, such as water 106. As indicated in FIGS. 1 and 3, the tank 44 is fixedly secured to the trailer frame 164 and movably attached at its front end to the rear frame members 40, 40*a* of the first trailer unit 26 by means of the trailer hitch or swivel bed 29. Tank 44 and the trailer 28 are supported at the rear thereof by tandem vehicle wheels 165. A conventional protective body or shell 166 is provided to enclose the tank 44 as indicated in FIGS. 1 and 3. Manhole covers 168, located above each cell 162*a* to 162*e*, provide access to the cells so that filters 170, which are removably mounted to each inner cell wall 172, can be replaced or cleaned, see FIG. 6. The filters are supported in frames 174, said frames being positioned about the edges of openings 176 in the lower central parts of partition walls 172, see FIGS. 3 and 5. As can be seen in FIG. 6, the return flow of water and sludge enters the upper rear cell 162*e* of the tank and, as the heavier sludge material settles to the bottom of the first cell, the light and smaller material will sift through the first filter and then on through to the next cell and filter. Each successive filter is made of smaller mesh material to trap the fine particles as they pass

through each successive cell to the last cell, from which the water is then pumped back to the spray nozzles. It can be seen that the sludge material will settle to the bottom of the tank **44**. Therefore, there is provided therein a clean-out opening indicated at **178** in the bottom of each cell or section **162***a* to **162***e*. There is also provided in the upper part of each wall **172** apertures **179**, see FIGS. **3** and **4**, whereby communication between each cell is accomplished so that a pressure drop is readily facilitated throughout the entire inner area of the tank **44**.

Referring back to the cutting units **48** and **50**, which in the previous description were described as being adjustable with relation to transporting and the accommodation thereof to different angular configurations of the road beds, there will now be described the cutting units with respect to the cutting and grinding modes of operation.

FIG. **12** shows a cross-sectional view of the cutting unit **50** which has the blades **78'** securely fixed on shaft **74**, the similar cutting unit **48** having blades **78** fixed on shaft **72**. As shown in FIGS. **12**, **13** and **22**, for groove cutting purposes the blades **78**, **78'** are evenly spaced apart a suitable distance, generally about three-fourth of an inch on center, as required to cut a kerf of about one-eighth of an inch deep, as indicated at B. For bump cutting purposes the blades like **78**, **78'** are closely spaced, as well known.

For groove cutting purposes, each end of each cutter **48** and **50** is provided with a depth control device. For this purpose, as indicated in FIG. **11**, cutter unit **48** has at its opposite ends the depth control devices **184** and **184**a; and cutter unit **50** at its opposite ends has the depth control devices **185**, **185**a. Each depth control device is carried by a support bracket like **186** welded to the frame **52** for the outer ends of the cutters and welded to the floating beams **88** and **90** for the inner ends of the cutters.

As shown in FIGS. **23** and **26**, bracket **186** is in the form of a box channel **251** acting as a shelf welded at its end **252** to the member **253** which represents either the floating beam or the frame member. The flat top **254** of the shelf **251** has arising therefrom spaced upright flat strips **255** and **256**, and laterally across them is welded a rear plate **257**, and spaced in front thereof is a front plate **258**. The plates **257** and **258** arise from and are welded at their lower ends to the top **254** of shelf **251**. The plates **257** and **258** are rectangular and with the adjoining top **254** of the shelf **251** form a space which receives the top of either the arm **188** of the depth control device **185** in FIG. **12** or the top of the arm **250** of the depth control device **284** in FIG. **23**. The plates **257** and **258** have aligned holes **259** and **260** to receive the shaft **261** of a bolt **189** having a head **262** behind plate **257** and at its front end having threads **263** for a nut **264**.

All four of these depth control devices for groove cutting are alike; and one of them, namely **185** at the outer end of cutter **50**, is shown in elevation in FIG. **12** wherein the frame member **60'** has a bracket **186**, the bolt **189** acting as a pivot support for the top of an inverted U-shaped rocker arm **188** having depending arms **188***a* and **188***b*. Arm **188***a* is at the front of the cutter **50** and terminates in a roller or wheel **190** which rides on the pavement ahead of the cutter. Arm **188***b* extends behind the cutter and has a pivotal support at **194** for an adjusting arm **192** which terminates at its lower end in a roller or wheel support **193** which rides on the pavement behind the cutter. The angular position of arm **192**, and hence the depth that the cutter can cut into the pavement, is controlled by operating the adjusting screw **196** mounted in the arm **192** and bearing against an abutment **183** on arm **188***b*.

For bump cutting purposes, a modified form of depth control is provided for each end of each cutter unit, a typical one being shown at **284** in FIGS. **23** and **26** wherein, after unfastening bolt **189** to remove each of the depth control devices like **184**, each bracket like **186** is employed to support a depth control device like **284** which has a single arm **250** which does not oscillate, but instead is rigidly fixed in the bracket. For this purpose, a wedge **264** is inserted between the top **254** of the shelf **251** and the underside of arm **250**, being removably held in position by screws like **266** having threaded engagement with the top **254** of the shelf **251**. The wedge **265** as shown in FIG. **23** extends on opposite sides of a vertical plane through the bolt **189** so that the arm **250** cannot swing either up or down about the axis of the bolt. The top **267** of the wedge **265** may be curved as shown in FIG. **23**, or otherwise shaped to conform to the shape of the undersurface of the arm **250**. As shown in FIG. **26**, the arm **250** is in the form of a hollow tube rectangular in cross section; and this form is preferred also for the depth control **188** in FIG. **12**. As the arm **250** in FIGS. **23** and **26** is fixed in position, the nut **264** is screwed down tight. In FIG. **23**, the arm **292**, adjusting screw **296**, pivot **294** and roller or wheel **293** are of the same construction and serve the same purpose as described for the corresponding elements shown in FIG. **12**.

It is apparent, therefore, that the bracket **186** may be used for either form of depth control shown in FIG. **12** or FIGS. **23** and **26**.

The depth control shown in FIG. **12** makes it possible to keep a very close tolerance on the depth of the kerf being cut, even when the surface of the pavement **104** raises or lowers during a cutting pass, such as shown in FIG. **18**. Since the center of the cutting unit is intermediate that of the two rollers **190**, **193**, any raising or lowering of a roller with respect to the other roller will cause only a slight rise to the cutting area of the blade **78'**. That is, if the rollers **193** on the rearward side of the blades are thus one inch above the level pavement, then the cutter axis is raised only one-half the amount because of the arms involved. It should be noted, at this time, that the above description is with respect to the grooving operation of the machine.

When the machine is to be used as a leveling machine to level high spots or areas on the road beds that have imperfections, as seen in FIG. **23**, rollers **190** and the front portion **188***a* of arm **188** are removed, thereby leaving only the trailing adjustable roller like **293** attached to one portion of the arm like **250**. Prior to the leveling operation, additional blades are added to the cutter units **48** and **50** so that no space is left between adjacent blades and a smooth surface can thereby be cut by adjusting the height of the cutter blades through the proper setting of rollers like **293**.

Referring to FIGS. **1** and **17**, there is shown a temperature-responsive means, indicated generally at **197**, located adjacent the trailing cutting edges of the blades **78**, said temperature-responsive means checking whether the cutters are being overworked due to the speed of travel. A trough member **198** is extended

downwardly from the frame **52**, providing a pickup for some of the sludge kicked off from the cutter blades, said trough having a thermal couple **199** connected to a signal light (not shown) which is illuminated as a warning signal if the sludge becomes too hot, thereby allowing corrective action so that the diamond blades **78** will not be damaged.

There is provided a separate means for laterally adjusting the position of frame **52** by repositioning hitch **55** and the slot means **58**, which allows the shifting of the outer ends of the cutter units to be positioned closely adjacent to a curb **105**, as seen in FIG. **16**. It is possible to extend the outer cutter blades to within **12** inches of said curb. When the frame **52** is needed to be laterally moved, the hydraulic cylinders are also relocated on additional brackets secured to the underside of the transverse beam **100**, as shown in phantom lines in FIG. **10**. In FIG. **11** the phantom lines show the relocation of hitch **55**, along with frame **52**.

It is undesirable for the Diesel engine **16** in the tractor **12** to operate at low gear and directly drive the equipment at slow speed because it would damage the blades **78, 78'** if they met an obstruction. Hence, a hydraulic drive from the engine **16** is provided, as indicated in the flow diagram in FIG. **24** and in FIG. **25**.

Engine **16** has a conventional clutch **200**. Motor **234** is connected to the input of a four-speed transmission unit T1 by a belt and pulley arrangement indicated at **207**. Transmission unit T2 has a clutch handle H1 to connect T2 in gear or in idle position out of gear. T1 has a four-speed gear transmission controlled by handle H2. When handle H1 is operated to make T2 idle, engine **16** drives through the four-speed transmission T1 to the drive shaft **242** and differential D and the wheels **24**. This condition prevails when traveling at comparatively high speed from one location to another one with the cutters in raised idle position. At this time fluid pressure retained in the cylinders holds the cutters in elevated position, a suitable catch, not shown, being provided, if desired.

When it is desired to cut bumps or grooves, the equipment is moved at comparatively slow speed, the engine **16** at this time driving the pumps P1, P2 through the five-speed transmission T5 and belt and pulley arrangement **206** and **208**, the clutch handle H3 being operated to disconnect the transmission T5 from the wheels **24** which are then driven by the fluid motor **234** through the transmissions T1 and T2. The handles **201** and **202** for the power take-off can be operated to either engage or disengage the drive of pumps P1 and P2 with respect to the engine **16**, as indicated by arrows **203** and **204**.

The fluid pressure from pump P1 is used to supply pressure to the two hydraulic cylinders **96** and **97**, and the two small hydraulic cylinders **101** and **102**. The pressure fluid line **210** leads from the pump P1 to control valves **212** and **213**, then through lines **214** and **215** to operate one cylinder **97**, and through similar lines **216** and **217** to operate the second cylinder **96**, the lines **214** and **216** being provided with pressure gauges G1 and G2 and pressure relief valves **218** and **220**, respectively. The relief valves **218** and **220** have lines like **221** connected to an oil reserve tank **222**. A return line **223** connects the oil reserve tank **222** to the pump P1, and line **223'** connects tank **222** to pump P2. The small cylinder **101** is operably connected to pump P1 through fluid lines **210, 224** and **225**, said line **225** being provided with a pressure gauge G4 and a pressure relief valve **226** between the cylinder and the control valve **228**, said valve **228** receiving fluid pressure from line **210**. The cylinder **102** is connected to pump P1 through fluid lines **210, 209** and **211**. Line **209** is provided with a pressure gauge G3 and a relief valve **219** between the cylinder and the control valve **205**. Pump P2 supplies pressure through line **230** and filter F to line **230*a*** leading to a power-steering device **229** which operates the cylinder **231** operably attached to the front steering wheels **22** of the tractor **12**. Flow lines **232** and **233** service the cylinder **231** between the steering device **229** and also provide a reservoir return line **233*a*** from the device **229** to the reservoir **222**. Pressure line **230**, in addition, via line **230*b*** supplies pressure to operate fluid motor **234** through a control valve **236**. Each control valve **212, 213, 205, 236** and **228** is connected to the reserve tank **222** by return line **235**. Lines **237** and **238** supply the pressure fluid from said valve **236** to the motor **234**.

The pressure relief valves like **218** insure that a suitable value of pressure is always available to operate the cylinders, the pump P1 being operated to supply a pressure in excess of the desired pressure, the surplus being by-passed. The gauges G1 to G4 are arranged on a suitable panel **246** adjacent the driver's seat **244** so that he can inspect the pressure being supplied to each cylinder and operate the valves like **212, 213**, etc., accordingly.

The modifications shown in FIGS. **27** to **29** have a number of features in common with the form shown in FIG. **20**. These common features include upright frame members in the form of I-beams like **36'** and **36** having a crosspiece like **37** carrying one member of a hitch like **55**, the companion hitch member being on a header like **54** having a hinge connection like **53** on a transverse horizontal axis with the forward ends of the U-shaped frame like **52**, the header also having a hinge connection on the same axis with floating beams for supporting the cutters, and hydraulic cylinders being provided for operating the frame and the floating beams.

In the form shown in FIG. **27**, two cutters are employed, cutter **300** having its outer end **301** carried by a bearing on floating beam **302** having a hinge connection **318** with header **354** on the same horizontal axis as the other hinges in FIG. **27**. The inner end **303** of cutter **300** has a bearing support in a frame member **304** which is fixed at its rear end **305** to the U-shaped frame **352**, while having a hinge connection **306** with header **354** on the above-mentioned horizontal axis. Cutter **307** has an inner end **308** having a shaft which overlaps the shaft of the inner end **303** of cutter **300**. The inner end **308** has a bearing support in a frame member **309** having a rear end **310** fixed to the frame **352** and having a front end having a hinge connection **311** with header **354** on the above-mentioned horizontal axis. The outer end **312** of cutter **307** has a bearing support in a floating beam **313** having a forward end having a hinge connection **314** with header **354** on the horizontal axis. Like FIG. **20**, FIG. **27** shows upright frame members **336, 336'** having a crosspiece **337** which carries one member of a hitch **355**, the companion member being carried by header **354**. Frame **352** has a hinge connection **353** between each of its side members and the header **354**. All of the hinge connec-

tions with header **354** are on the same transverse horizontal axis.

FIG. **27** shows the inner ends of cutters **300** and **307** spaced apart the same distance as the cutting disks as described in connection with FIG. **20,** for groove cutting purposes.

The construction of the rear ends of the floating beams in all the forms in FIGS. **27** to **29** is like the construction shown in FIG. **20.** In particular, in FIG. **27,** the cylinder **315** which operates the frame, here shown as a single cylinder at the center of the frame, is operative to raise the frame and carry with it the rear ends of the floating beams to lift the cutters to idle position.

As in FIG. **20,** in all the forms in FIGS. **27** to **29** the weight of the engine which drives the cutters is carried by the frame, being mounted on the side members like **60** and **60'** in FIG. **20** whereby the weight of the engine is effective to hold down the outer ends of the cutters to cutting engagement with the pavement. The inner ends of the cutters in FIG. **20** are urged to cutting position by cylinders **101** and **102,** whereas in FIG. **27** the outer end of cutter **300** is urged into cutting position by a cylinder **316** at the rear of the floating beam **302,** the outer end of cutter **307** being urged to cutting position by a cylinder **317** at the rear of beam **313.**

For example, the cylinders **101** and **102** in FIG. **20** may have a throw of one-and-one-half inches each side of a mean position, the pistons of these cylinders having a diameter of 2 ½ inches. Cylinders **96, 97** may have a throw of 16 inches, their pistons having a diameter of three inches. When in cutting position, the weight of the engine holds the outer ends of the cutters in FIG. **20** to the work so that the total downward force on the outer ends of the cutters is equal to that weight plus the adjustable force provided by cylinders **96, 97.** A somewhat higher pressure is supplied to the cylinders **101, 102** to equalize the pressure on the outer ends of the cutters because the downward pressure on the inner ends of the cutters is not influenced by the weight of the engine, but is due solely to the pressure exerted by the cylinders **101** and **102.**

In FIG. **28,** a single cutter **319** is shown; and as indicated, this may have a length comparable to the overall length of the two cutters of FIG. **27.** One end **320** of cutter **319** has a bearing carried by floating beam **321** having a hinge connection **322** with the header **323,** the rear end of beam **321** having a hydraulic cylinder **324** to urge the associated end of the cutter to cutting position. The other end **325** of cutter **319** has a bearing support in floating beam **326** having a pivotal connection **327** with the header, the rear end of beam **326** having a cylinder **328** for urging the cutter to cutting position. At the center of the U-frame **329** is provided a hydraulic cylinder **330** for lifting cutter **319** to idle position.

In FIG. **29,** the U-frame **331** is operated by a hydraulic cylinder **332** at the rear center of the frame. Two cutters are shown, cutter **333** overlapping the inner end of cutter **334** as indicated at **335,** for bump cutting purposes. The opposite ends of cutter **333** are mounted in floating beams **356** and **357.** The opposite ends of cutter **334** are mounted in floating beams **358** and **359.** Each of the floating beams and each of the side members of frame **331** has a hinge connection on axis A-A with the header **360.** Each floating beam has a hydraulic cylinder as indicated at **361, 362, 363** and **364.** The cylinders in FIG. **29** serve the same purpose as described in connection with FIGS. **20, 27** and **28.**

In FIGS. **27** to **29,** a universal bearing is provided for each end of each cutter, similar to the showing in FIG. **21** previously described.

The invention and its attendant advantages will be understood from the foregoing description and it will be apparent that various changes may be made in the form, construction and arrangement of the parts of the invention without departing from the spirit and scope thereof or sacrificing its material advantages, the arrangements hereinbefore described being merely by way of example; and I do not wish to be restricted to the specific forms shown or uses mentioned, except as defined in the accompanying claims.

We claim:

1. Liquid coolant supply for rotary pavement cutter wherein a vehicle having traction wheels is provided for transporting a rotary pavement cutter, means being provided for supplying a liquid coolant to the cutter, said cutter being housed in a vacuum chamber having a side wall having a lower edge in sealing contact with the pavement around the cutter, a tank, means for creating a reduced fluid pressure in said tank, the improvement wherein said chamber has a rectangular series of upright tubular suction nozzles with conduit means connected to said tank and to said nozzles for returning the coolant and cuttings to the tank, said nozzles having lower ends and having a length sufficient for said lower ends to contact the pavement during operation of said cutter.

2. Liquid coolant supply according to claim **1** in combination with a trough for receiving the coolant ejected by the cutter, temperature-responsive means in said trough in position to be contacted by the ejected coolant, and a signal controlled by said temperature-responsive means.

3. Liquid coolant supply for rotary pavement cutter wherein a vehicle having traction wheels is provided for transporting a rotary pavement cutter, means being provided for supplying a liquid coolant to the cutter, a movable support for said cutter, an engine for operating said cutter carried by said support, a vacuum chamber having a side wall having an upper edge carried by said support and having a lower edge in sealing contact with the pavement around said cutter, the improvement comprising a manifold carried by said support and arranged in said chamber, said manifold having a connection to a vacuum supply and having a series of upright suction nozzles having upper ends opening into said manifold, said nozzles having lower ends and having a length sufficient for said lower ends to contact the pavement, said nozzles extending around said cutter, and means for raising or lowering said support to locate the cutter and the lower edge of said wall and the lower ends of said nozzles into or out of contact with the pavement.

4. Pavement cutting machine comprising an elongated rotary pavement cutter device, a liquid coolant supply for said cutter device, a vehicle having traction wheels for transporting said cutter device, said vehicle having a movable support for said cutter device, an engine for operating said cutter device, a vacuum chamber having a wall extending around said cutter device and carried by said support, said wall having a lower edge extending around said cutter device in position to form a sealing contact with the pavement the improve-

ment wherein a manifold is carried by said support, in elevated position above the pavement, said manifold having a connection for a vacuum supply and having a series of tubular upright suction nozzles depending from said manifold and extending around said cutter device, said nozzles having upper ends opening into said manifold and having a length sufficient for its lower ends to contact the pavement, and means for raising or lowering said support to locate said cutter device and the lower edge of said wall and the lower ends of said nozzles out of or into contact with the pavement.

5. Pavement cutting machine according to claim 4, said rotary pavement cutter device comprising two elongated cutters arranged end-to-end, said cutters extending transversely of the direction of travel of said vehicle, said manifold and said suction nozzles extending around both of said cutters.

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