

Sept. 20, 1971

J. E. KEPPLER

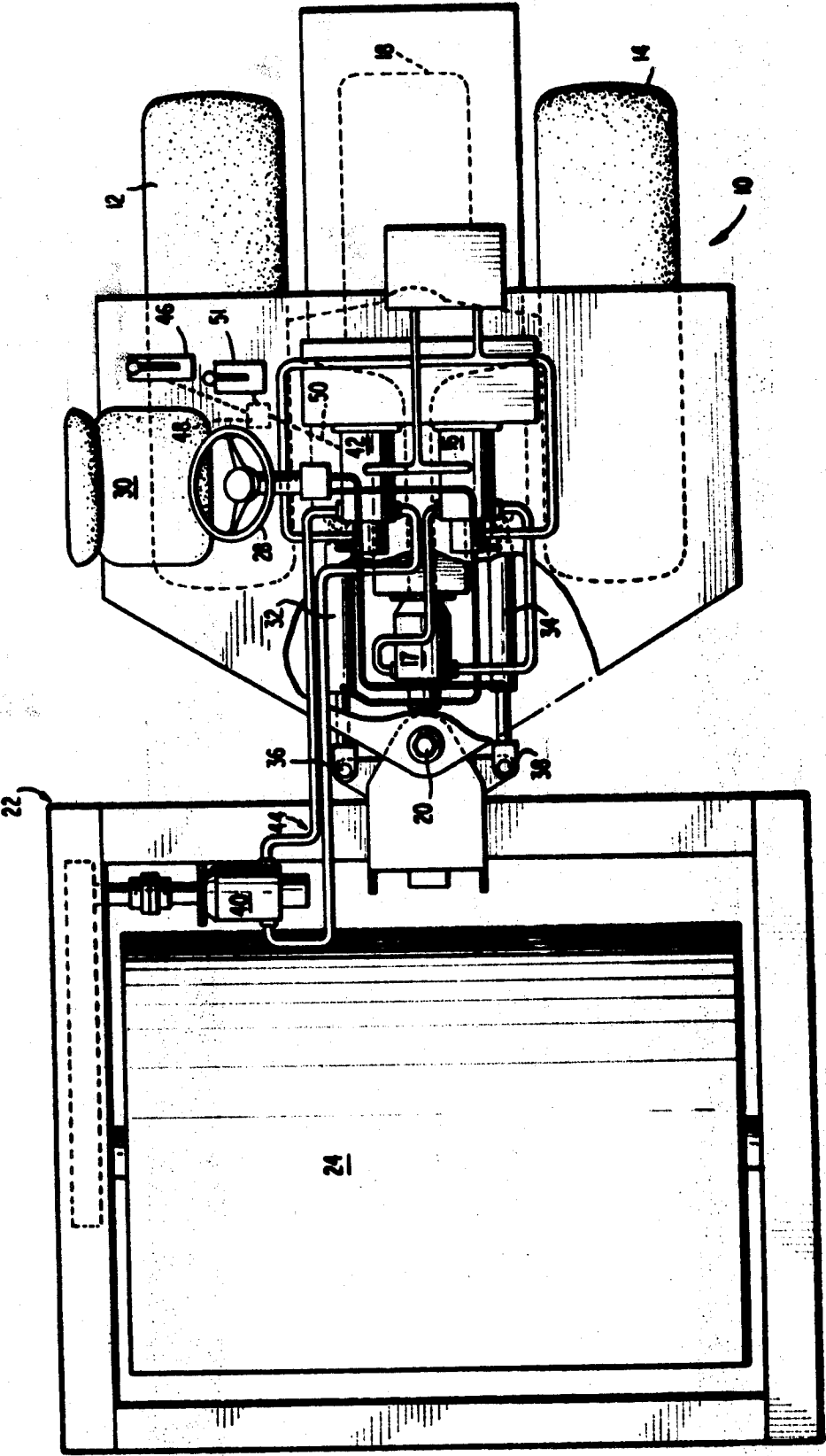
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VIBRATORY ROLLER COMPACTING APPARATUS AND METHOD

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FIG. 1



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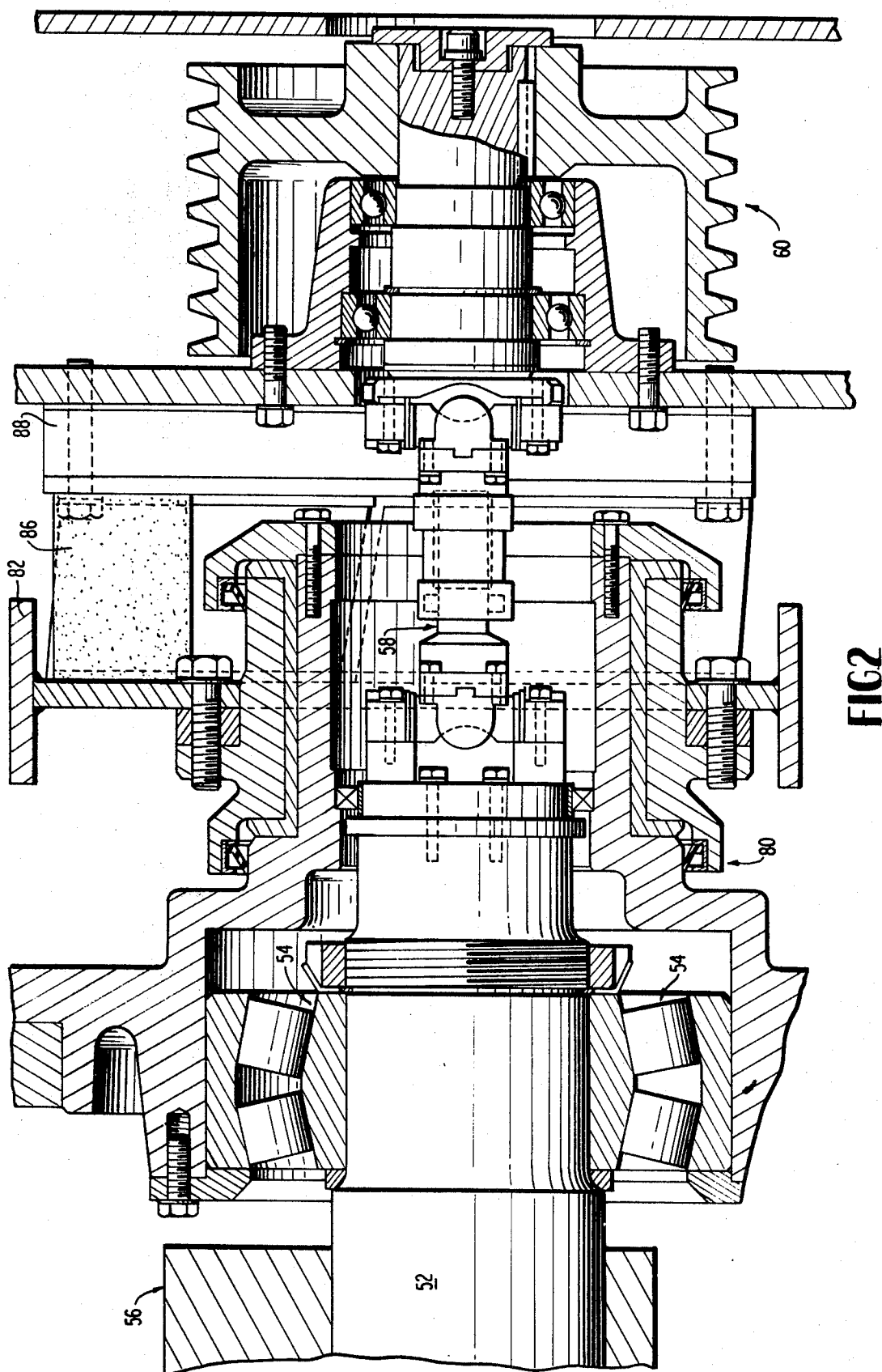


FIG2

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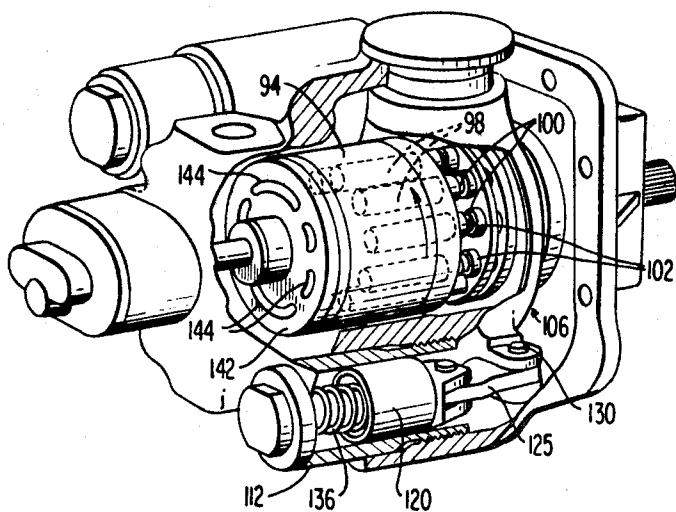
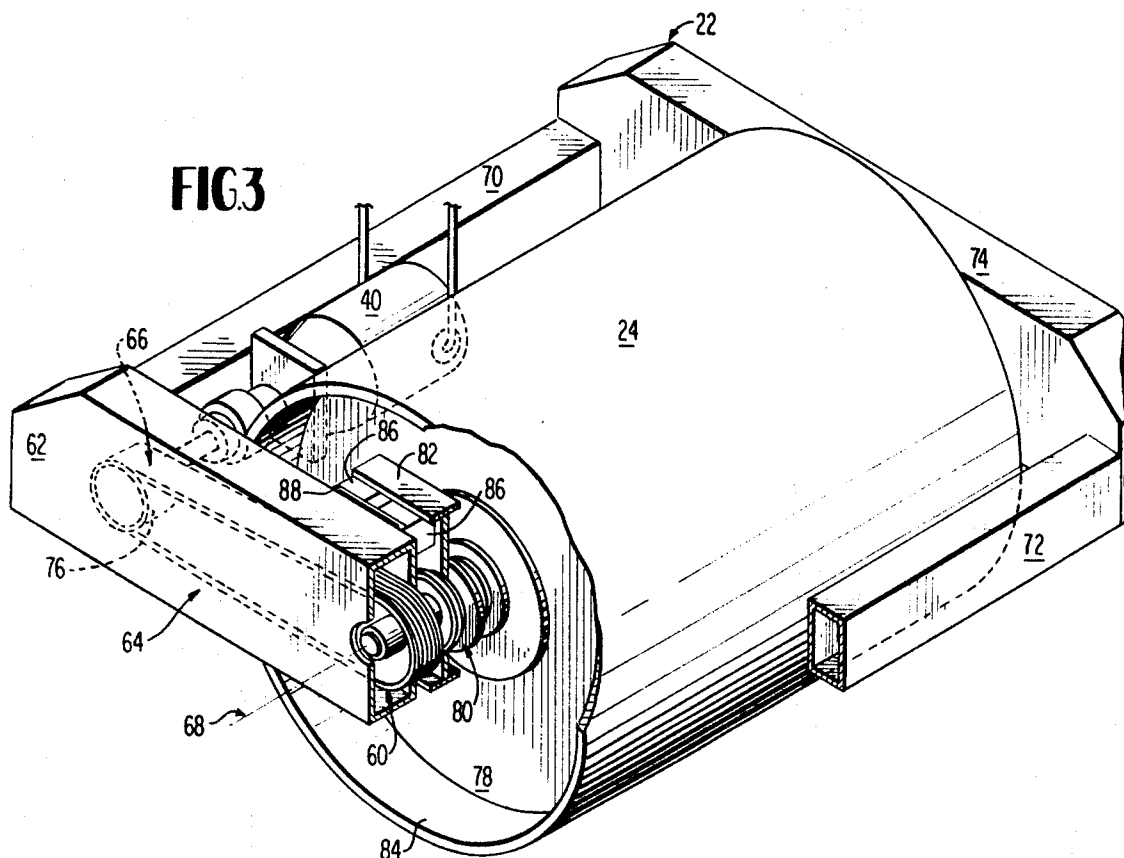
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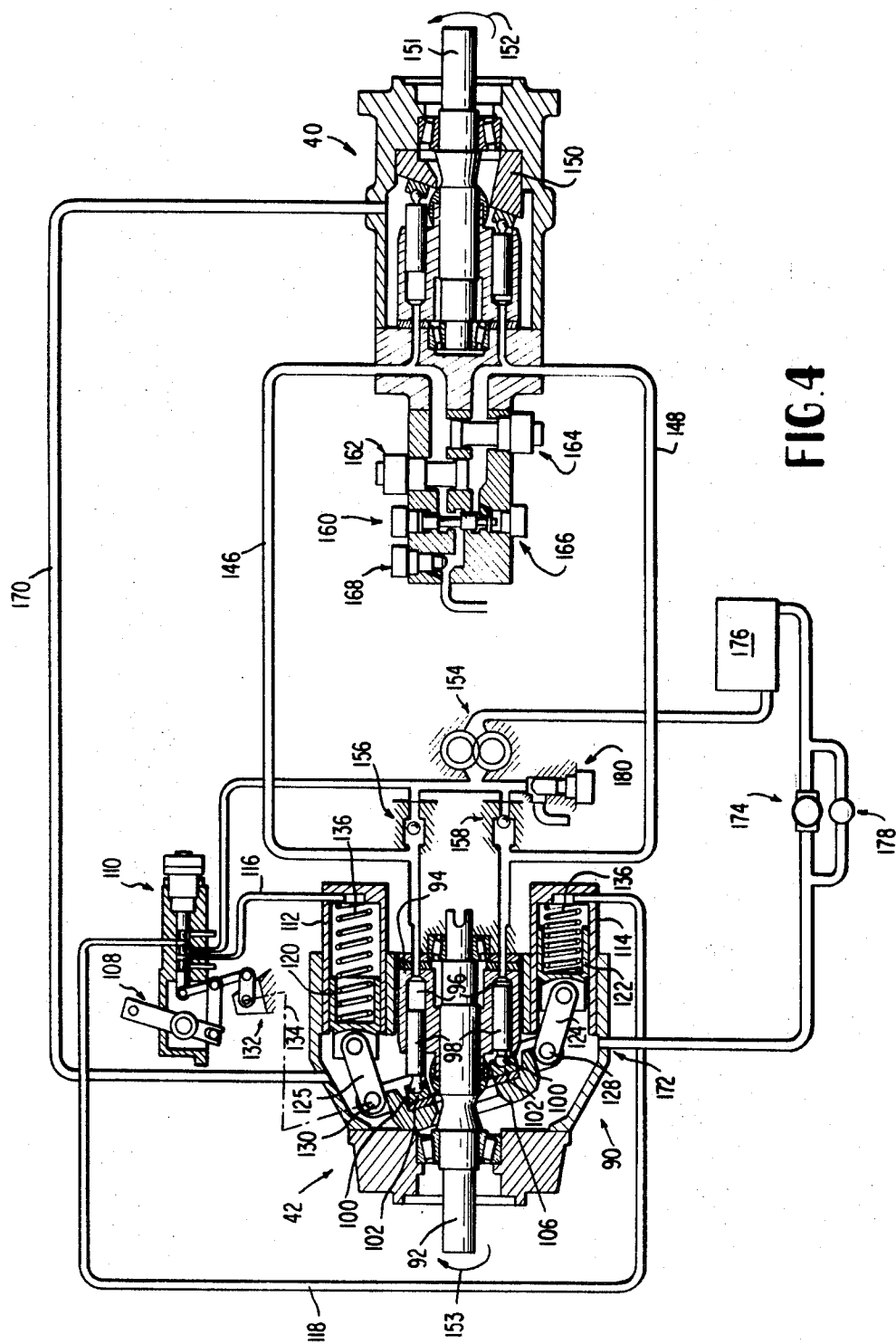
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VIBRATORY ROLLER COMPACTING APPARATUS AND METHOD

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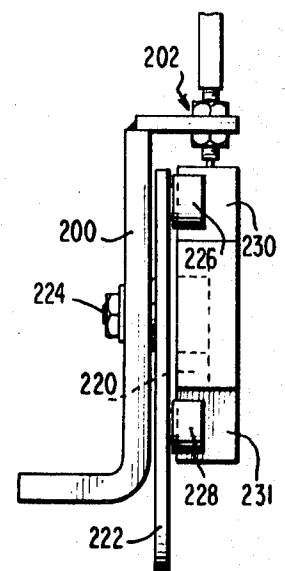
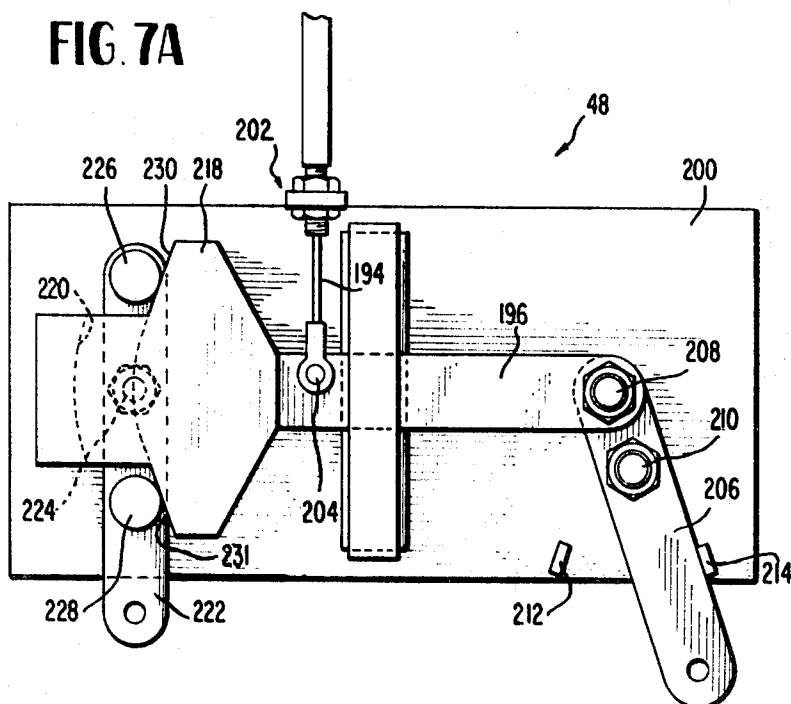
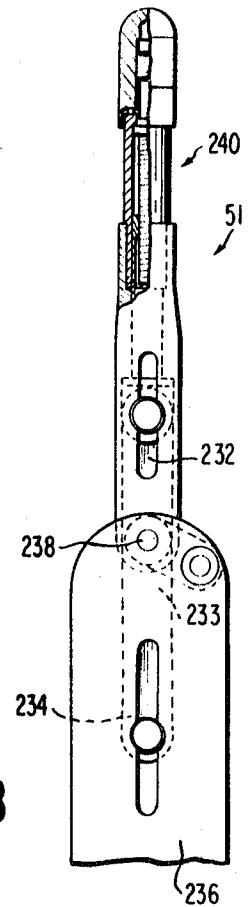
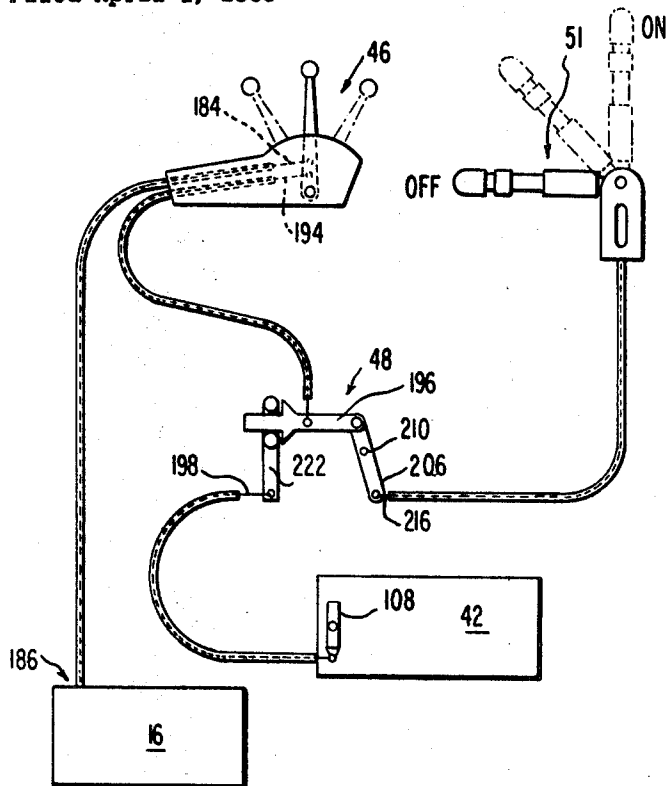
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VIBRATORY ROLLER COMPACTING APPARATUS AND METHOD

John E. Keppler, San Antonio, Tex., assignor to Tampo Manufacturing Company, Inc., San Antonio, Tex.

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U.S. Cl. 94—50V

16 Claims

ABSTRACT OF THE DISCLOSURE

A self-propelled vibratory machine including a frame resiliently mounting a compacting roller for rotation, and eccentric means, rotatable about the roller axis, for vibrating the roller. A variable speed hydrostatic transmission including a reversible, variable displacement pump in closed-loop fluid communication with a fixed displacement motor is in continuous driving relationship with the eccentric means and is operable to control the speed and direction of rotation thereof. A control linkage automatically correlates the direction of rotation of eccentric means with the translating direction of travel of the machine. Positive braking of the eccentric means, in approximately three revolutions thereof, minimizes the period of resonance between the frame and the vibrating roller.

BACKGROUND OF THE INVENTION

This invention relates to a vibratory roller. More particularly, this invention relates to improvements in the drive of a rotatable eccentric means for vibrating the roller.

In machines for compacting ground surfaces, it is known to employ freely rotatable rollers vibrated by eccentric means rotating independently of the roller. Such rollers are often resiliently suspended by a frame.

It has been common practice to rotate the eccentric means, during a compacting operation, at a speed significantly greater than the range in which the vibrating roller and the supporting frame are in resonance. Before reversing the direction of travel of the machine, the rotation of the eccentric means is usually stopped in order to avoid grooving of the compacted surface by the vibrating roller. During the eccentric slowing process, either prior to a travel direction change or for any other purpose, the eccentric speed passes through the range in which the vibrating roller and the supporting frame are in resonance.

Within this range, portions of the impulses produced by the eccentric are stored within the system by the resilient frame suspension. Thus, heavy shocks due to increased amplitude of compacting vibration are transmitted through the suspension to the roller and to the surface to be compacted.

If the deceleration of the rotating eccentric is not accomplished through positive braking action, as many as nineteen revolutions and about two seconds may be required before the eccentric speed passes through the resonance range.

In asphalt compaction, this extended period of resonance is unacceptable insofar as grooves or ripples may be produced in the asphalt surface. It would, therefore, be highly desirable to provide for high force, positive, dynamic braking of the eccentric so as to substantially minimize the period of resonance, thereby rendering rollers vibrated by rotating eccentrics acceptable for asphalt compaction.

Moreover, it would also be desirable to provide for an acceleration rate of the eccentric, by means of a high power input, that would also avoid prolonged periods of resonance while bringing the eccentric to its selected operating speed.

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In many instances, the rotating eccentric means is conveniently housed within the compacting roller for rotation about the roller axis. Although such an assembly may be extremely desirable, it does present problems from both the standpoint of producing non-uniformities in the surface being compacted and the standpoint of tractive effort necessary for machine propulsion.

For example, it has been found that as a result of rotation of the eccentric means, the freely rotatable compacting roller tends to be induced to rotate in an angular direction opposite to that of the eccentric rotation. When the machine is stationary, the roller does rotate in such a direction. The rate of this induced rotation of the roller is considerable when compared with the normally slow speed of rotation of the roller induced by the slow vehicle propulsion during a compaction operation.

Thus, it is apparent that if the eccentric means is rotatable in only one direction, propulsion of the vehicle in at least one direction of translation tends to rotate the roller in a direction opposite to the direction of rotation induced by the eccentric means. This produces a tendency for the roller to slide along the surface and to cause non-uniform compaction and cracks.

Moreover, the tractive effort needed to propel the vehicle in at least one translating direction is unnecessarily increased by the induced rotation of the roller in a reverse direction.

It would, therefore, be highly desirable to provide for two directions of rotation of an eccentric means housed within, and rotating about the axis of, a freely rotatable compacting roller of a vibratory machine, and to correlate the direction of rotation of the eccentric means with the direction of translation of the compacting machine.

Furthermore, it would be particularly advantageous to provide for automatic reversing of the direction of rotation of the eccentric means responsive to changes in the direction of translation of the vehicle. Such automatic reversing would not only minimize the number of controls that need be regulated by an operator, but would also avoid the possibility of incorrect rotation correlation that may defeat the purposes of a two-directional rotating eccentric means.

OBJECTS AND SUMMARY OF THE INVENTION

It is, therefore, a general object of the invention to provide a vibratory roller designed to obviate problems of the type previously described.

It is a particular object of the invention to provide for rapid, positive, dynamic braking of a rotating eccentric means for a vibratory compacting roller.

It is a related object of the invention to provide a drive for a rotating eccentric means of a vibratory compacting roller wherein a high power input accomplishes rapid acceleration of the eccentric.

It is an independent object of the invention to provide driving means for a rotating eccentric means housed within, and rotatable about the axis of, a vibrating compacting roller wherein the driving means accomplishes two-directional rotation of the eccentric means, with the direction of rotation being correlated to the direction of translation.

It is a related object of the invention to provide a control for such a driving means that automatically correlates the direction of eccentric means rotation with the direction of vehicle translation.

It is yet another object of the invention to provide a method of compacting asphalt with a vibratory compacting roller by rotating an eccentric means mounted within the roller about the roller axis in an angular direction correlated with the direction of translation of the compacting machine.

It is a still further object of the invention to provide an

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improved method for compacting surfaces with a vibratory compacting roller by rapidly and dynamically decelerating a rotating eccentric means.

THE DRAWINGS

Other objects and advantages of the present invention will become apparent from the following detailed description of a preferred embodiment as illustrated in the accompanying drawings, in which:

FIG. 1 is a schematic plan view of a self-propelled vibratory compacter machine according to a preferred embodiment of the invention;

FIG. 2 is a partial cross sectional view of the rotating eccentric means used in the machine of FIG. 1;

FIG. 3 is a perspective view illustrating the resilient mounting of the compacting roller used in the machine of FIG. 1;

FIG. 4 is a schematic illustration of the hydrostatic transmission providing the drive and brake for the eccentric means shown in FIG. 2;

FIG. 5 is a partial, perspective view of the pump illustrated in FIG. 4;

FIG. 6 is a schematic illustration of the control system for the machine propulsion and eccentric means rotation;

FIG. 7A is a detailed plan view of the automatic eccentric means rotation reversing linkage schematically illustrated in FIG. 6;

FIG. 7B is an end elevational view of the automatic reversing linkage shown in FIG. 7A; and

FIG. 8 is an elevational view of a memory throttle used in the control system of FIG. 6.

DETAILED DESCRIPTION

Referring now to FIG. 1, a schematic view of a self-propelled vibratory compacting machine according to a preferred embodiment of the invention is there shown.

The machine includes a tractor frame 10 supported for ground traversing movement on two spaced parallel wheels 12 and 14. These wheels, and therefore the vehicle, are propelled in either a forward or reverse direction by a hydrostatic drive including a pump and a motor, respectively, schematically illustrated at 16 and 17. The pump of this drive is driven by an engine, schematically shown at 18, of any suitable type.

Pivotaly attached to the forward end of the tractor frame 10 for movement about a generally vertical axis 20 is a roller support frame 22. This roller support frame 22 resiliently supports a freely rotatable roller 24.

Located within the roller 24, and mounted for independent rotation with respect thereto, is a rotatable eccentric means. This eccentric means, as well as the resilient suspension of the roller 24, will be hereinafter more fully described.

The direction of travel of the vehicle is controlled by a steering wheel 28 mounted within the tractor frame 10 adjacent an operator seat 30. This steering wheel is hydraulically coupled to a pair of spaced, parallel piston and cylinder assemblies 32 and 34. The piston rods of these assemblies are pivotally coupled to the roller support frame 22 on opposite sides of the generally vertical axis 20, as indicated at 36 and 38.

It will be appreciated that reciprocation of the pistons of these cylinder assemblies 32 and 34 provides for turning maneuverability of the vehicle by pivoting the roller support frame 22 of the integrated, self-propelled unit about the generally vertical attachment axis 20.

A drive motor 40 for rotating the eccentric means is mounted on the roller support frame 22 by supports (not shown). This motor is hydraulically coupled to a pump 42, mounted on the tractor frame 10, by means of a hose assembly 44. This pump 42 is driven by the engine 18.

The pump 42 and the motor 40 comprise a variable speed, reversible hydrostatic transmission hereinafter more fully described in connection with FIGS. 4 and 5.

A propulsion throttle lever, schematically illustrated at 46 in FIG. 1, controls the direction and speed of rota-

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tion of the pump 16 of hydrostatic propulsion transmission, and thereby controls the direction and speed of travel of the machine. This lever 46 is also operatively coupled to an automatic direction control means 48 for the eccentric. This automatic control means 48 is hereinafter more fully described in connection with FIGS. 6, 7A and 7B.

The control means 48 in turn is connected to the pump 42 of the eccentric means transmission, as indicated at 50.

The purpose of the control is to automatically correlate the direction of rotation of the eccentric means with the direction of translation of the vehicle. The speed of the eccentric is controlled by a memory throttle 51.

Referring now to FIG. 2, the eccentric means for the roller 24 is there shown. This eccentric means includes a shaft 52 extending coaxially into the roller 24.

The shaft is mounted for rotation independently of the freely rotatable roller 24, for example, by means of bearings shown at 54. Within the confines of the roller, the shaft 52 is provided with eccentric weight means 56 rotatable therewith. The shaft 52 is flexibly connected by a drive connection 58 to a rotatable sheave 60.

This sheave 60 may be located within the confines of one of the side girders 62 of the frame 22 (FIG. 3). Suitable flexible drive belts 64 connect the sheave to the output of the frame supported drive motor 40, as indicated at 66.

Output rotation of the motor 40 in either direction thereby causes rotation of the shaft 52 of the eccentric means in the same direction. As the shaft 52 is rotated, the eccentric weight means 56 develops vibratory forces which cause vibratory oscillation of the resiliently mounted, independently rotatable roller 24.

In FIGS. 2 and 3, the resilient mounting of the compacting roller 24 on the frame 22 is illustrated. The roller 24 is hollow, and generally cylindrical and is mounted for free rotation about a generally horizontal axis, indicated at 68.

The frame 22 includes front and rear ends 70 and 72, respectively, and longitudinally extending side girders 62 and 74. These girders are hollow, box-like members in one of which the sheave 60 and flexible drive members 64, as well as the final output member 76 connected to the motor 40, are located.

The roller 24 is provided with two axially recessed, radially extending, end plates 78 (only one of which is shown), each spaced laterally inwardly from the adjacent one of the side girders 62 and 74. Fixedly secured to the end plate 78, and concentric with the roller axis, are two hollow hubs indicated generally at 80. These hubs are supported for rotation in vertically supporting beams 82. The beams 82 are spaced laterally from and are parallel to the adjacent side girders and are located within the confines of a hollow, cylindrical, projection 84 forming a continuation of the roller external surface.

Resilient suspension members 86 fixedly connect each supporting beam 82 to rigid spacing panels 88 mounted on the side girders. These resilient suspension members 86 permit limited relative motion between the roller 24 and the frame 22 in all directions.

For a more detailed description of the resilient mounting for the roller, as well as the flexible connection 58 between the sheave 60 and eccentric shaft 52, reference may be had to U.S. Pat. No. 3,411,420 (the disclosure of which is hereby incorporated by reference), assigned to the assignee of the present invention.

Referring now to FIG. 4, a schematic diagram of the previously identified hydrostatic transmission for driving and positively decelerating the eccentric means is there shown. It will be appreciated that this transmission is conventional and forms no part of the present invention, per se. However, the transmission, when properly sized, provides for rapid acceleration, and positive dynamic braking of the eccentric means in about three revolutions thereof. This obviates the problems associated with resonance be-

tween the roller support frame 22 and the vibrating roller 24.

Moreover, this combination also permits control of the direction and speed of rotation of the eccentric vibrating means, so as to minimize problems associated with both non-uniform compaction and unnecessary tractive effort required for propulsion of the machine. This is accomplished by correlating the direction of rotation of the eccentric means with the direction of translation of the vehicle. Thus, the roller is not induced, by the eccentric means rotation, to rotate in a direction opposite to that caused by machine translation.

The transmission is comprised of the previously identified reversible, variable displacement pump 42 and fixed displacement motor 40. The pump 42 includes a housing 90 in which an input shaft 92 is mounted for rotation about the central axis thereof. Concentrically mounted about the input shaft 92, and fixedly attached thereto, is a cylinder block 94 (FIG. 5). Within this block a plurality of circumferentially spaced, longitudinally extending cylinders 96 are disposed in an annular ring.

Mounted for reciprocation within each of the cylinders 96 is a piston 98. The rod ends of these pistons are generally spherical, as indicated at 100, and are universally mounted in spherical shoes 102 which are rotatable with the cylinder block 94.

The variable displacement and reversing characteristics of the pump 42 are provided by a swashplate 106. This swashplate 106 is mounted for pivotal motion solely about a single axis perpendicular to that of the input shaft 92, and is stationary with respect to all other perpendicular axes.

Control of the swashplate angle controls the displacement of the pump and, therefore, the speed of the motor 20 and the eccentric means. This speed control is provided by a control handle 108 operatively associated with a displacement control valve, schematically illustrated at 110. This control valve 110 is in fluid communication with first and second servo control cylinders 112 and 114, as indicated by flow lines 116 and 118, respectively.

These servo cylinders 112 and 114 are located in the pump housing 90, and their pistons 120 and 122 are connected by respective pivot links 124 and 125 to diametrically opposite portions of the swashplate, as indicated at 128 and 130.

A follow up linkage 132 is coupled to the swashplate as schematically illustrated at 134, to provide a feed back linkage system. The swashplate 106 is spring-loaded to a neutral position, by springs 136 (FIG. 5) to insure a positive neutral, i.e. no swashplate angle.

In FIG. 4, the control handle 108 is shown as pivoted clockwise to obtain a first direction on the swashplate angle corresponding to one direction of rotation of the eccentric means. This is accomplished by pressurizing the one servo cylinder 112 while exhausting the other servo cylinder 114 through the displacement control valve 110. If the oil in the circuit becomes pressurized to a point that tends to overcome the preset swashplate position, the follow up linkage 132, which connects the swashplate to the displacement control valve 110, activates the control valve to supply adequate pressure to the extended servo piston, thereby to maintain the swashplate in its preset position.

It will be appreciated that since the control valve is spring centered, both servo cylinders 112 and 114 are equally pressurized when the control handle 108 is in its neutral position (i.e. vertical in connection with the orientation shown in FIG. 4). Moreover, if the control handle 108 is pivoted counterclockwise (as viewed in FIG. 4), the swashplate 106 will assume a tilt angle corresponding to the direction of rotation of the eccentric means opposite to that caused by a clockwise movement of the handle.

With the swashplate at an angle, some of the piston rod ends 100 are extended and others depressed. Rotation of the cylinder block 94 thus results in a flow from certain

of the cylinders 96 and a suction by the remaining ones of these cylinders.

An annular valve plate 142 (FIG. 5) is mounted adjacent the end of the cylinder block. This valve plate is provided with a plurality of openings 144 to facilitate flow into and out of the cylinders of the pump.

The previously identified motor 40 is mounted on the roller support frame 22, remote from the pump 42. However, this motor 40 is in continuous, closed circuit, fluid communication with the pump 42 by means of flow lines 146 and 148. The parts of the motor are substantially identical to those of the pump 42 and will not be discussed in detail. It will suffice to say that the motor is of the fixed displacement type, i.e. the motor swashplate 150 is at a constant angle with respect to an axis perpendicular to the motor output shaft 151.

With the control handle in the clockwise pivoted position indicated in FIG. 4, high pressure oil exists in the lower flow line 148 between the pump and the motor 40. Low pressure oil exists in the upper flow line 146, between the motor 40 and the pump 42. The hydrostatic fluid causes the motor output shaft 151 to rotate in the same angular direction as the pump input shaft 92 as indicated by the arrows 153 and 152 (FIG. 4).

In order to provide oil in the transmission for cooling purposes, and to provide oil under positive pressure on the low pressure side of the pump-motor circuit, a charge pump 154 is included in the system. This charge pump also provides sufficient oil under pressure for control purposes and for internal leakage make-up. One of two identical charge pump check valves 156 and 158 directs the charged oil to the low pressure side of the main circuit. The other check valve is maintained in closed position by the high pressure oil on the other side of the main circuit.

As will be apparent, hydrostatic oil exists in the main circuit in a continuous closed loop. The quantity of oil displaced is a function of the pump speed and the amount of tilt of the swashplate. This controls the speed of the eccentric means. The direction of oil displacement is determined by the orientation of the tilt angle of the pump swashplate. This controls the direction of rotation of the eccentric means.

A manifold valve assembly 160, including two high pressure relief valves 162 and 164, a shuttle valve 166 and a charge pressure relief valve 168, is connected across the main fluid circuit. The pressure relief valves 162 and 164 prevent any sustained abnormal pressure surges in either of the main circuit flow lines 146 and 148. During rapid acceleration or deceleration, as well as in response to a sudden load application, these relief valves 162 and 164 dump oil from the high pressure line to the low pressure line of the main circuit.

The shuttle valve 166 establishes a fluid circuit between the low pressure main circuit line (146 in FIG. 4) and the charge pressure relief valve 168. In the event that excess cooling oil is added to the circuit by the charge pump 154, this excess cooling oil is thereby removed by the charge pressure relief valve 168. It will also be apparent that the charge pressure relief valve 168 functions to control the charge pressure level.

Since the shuttle valve 166 is centered by springs (not shown) to a closed position, none of the high pressure oil is lost from the circuit during the transition of high pressure and low pressure between the main circuit lines 146 and 148.

Excess oil that may exit from the charge pressure relief valve 168 enters the motor casing and flows to the pump casing through a free flow oil line 170. Thus, the charge pump cooling oil is circulated to aid in cooling. Cooling oil exiting from the pump casing, as indicated at 172, passes through a heat exchanger 174 and is returned to a reservoir 176. A valved bypass circuit 178 is provided at the heat exchanger 174 to prevent back pressure that may be caused by cold oil.

At times when the main pump 42 is in neutral, the shut-

the valve 166 is normally closed. A charge relief valve 180 in the charge pump 154 directs excess oil from the charge pump to the cooling circuit in such instances. It will be appreciated that under such conditions, cooling flow is not admitted to the motor. However, the motor being at rest, and the eccentric means being stationary, such cooling flow is not necessary.

As previously mentioned, the output shaft 151 of the motor 40 is operatively coupled to the sheave 60 by the flexible belts 64. With the pump 42 and motor 40 of the transmission in continuous closed-loop communication, and with the charge pressure in the closed-loop constantly maintained, substantially instantaneous, hydrostatic response is obtained in the rotation of the eccentric means by movement of the transmission control handle 108.

No clutch is necessary between the motor and the eccentric means. Moreover, the closed-loop system insures positive, and immediate dynamic braking of the vibrating means. It is apparent that means for positively braking the eccentric means, other than the hydrostatic transmission described, are within the scope of the invention.

The control handle 108 is stepless, and therefore the direction and speed of rotation of the eccentric means is potentially infinitely variable from zero to its maximum value.

For a more detailed description of the structure and mode of operation of the transmission, reference may be had to the "Engineering Application Manual, Bulletin 9565," available from Sundstrand Hydro-Transmission, LaSalle, Ill. The disclosure of the bulletin is hereby incorporated by reference.

Referring now to FIG. 6, a schematic diagram of the control system for the propulsion transmission and the vibrating means transmission is there shown.

The previously identified propulsion control throttle 46 is pivotally mounted at a convenient location in the tractor frame 10 for manipulation by an operator. A Bowden cable 184 attached to one end of this throttle 46, as indicated at 186, is coupled to the propulsion transmission pump schematically illustrated at 16.

Movement of this cable 184 controls the angle of a swashplate in the pump of the propulsion transmission. This transmission may be substantially identical to that described in connection with the eccentric means control.

Thus, the direction of propulsion, as well as the speed, may be controlled by operation of the stepless propulsion control throttle 46 between the dotted positions shown.

In FIG. 6, the previously identified memory type control throttle 51, hereinafter more fully described, is schematically shown. This throttle 51 controls the speed of the eccentric means. In order to obviate the necessity of the operator having to correlate the direction of rotation of the eccentric means with that of the machine translation, the previously described automatic direction control means schematically shown at 48 is provided. This control means 48 functions to correlate the direction of rotation of the eccentric means with the direction of machine translation.

A second Bowden cable 194 is connected to the end of the propulsion throttle 46 adjacent the first Bowden cable 184. This second cable 194 is operative to move a switching link 196 to either of two positions, corresponding respectively to forward and reverse translation movement of the machine. In one of these positions, the switching link 196 is operative by means of a third flexible Bowden cable 198 to pivot the swashplate control handle 108 counterclockwise.

In the other position of the switching link 196, the cable 198 causes the swashplate control handle 108 to pivot clockwise. Thus, the operator need only move the eccentric means control throttle 51 between its stop and pivoted positions in one angular direction. The position of the propulsion control throttle 46 will automatically insure a correct direction of rotation of the eccentric means by displacement of the switching link 196.

Referring now to FIGS. 7A and 7B, the vibrating means direction control means 48 is there shown in detail. This control means includes a support bracket 200 on which the end of the sleeve of the second Bowden cable 194, remote from the propulsion control throttle 46, is mounted, as indicated at 202. The end of the Bowden cable 194 itself is attached to the control link 196 as indicated at 204.

One end of the control link 196 is pivotally attached to one end of a drag lever 206 as indicated at 208. This drag lever 206 is in turn pivotally mounted on the support bracket 200, as indicated at 210, for movement to any pivotal position between two stops 212 and 214 on opposite sides of the pivot axis. The other end of the drag lever 206 is connected to a fourth Bowden cable 216 (FIG. 6), the remote end of which is coupled to the memory throttle 51.

The free end of the control link 196 is provided with an enlarged camming head 218 having a transversely extending, curved camming groove 220 in a projecting end thereof. This camming groove 220 faces toward the bracket 200 and is generally superposed above a follower lever 222.

The follower lever 222 is pivotally mounted on the bracket 200 as indicated at 224. Provided on the follower lever and equally spaced on opposite sides of the pivot point, are two generally cylindrical follower projections 226 and 228 which face the camming groove 220. One end of the follower lever 222 is connected to the previously identified third Bowden cable 198, the other end of this cable 198 being attached to the control handle 108 of the variable displacement pump 42 (FIG. 6).

When the memory throttle 51 is in its full line, or stop position (as shown in FIG. 6), the drag lever 206 is in its off position, adjacent one stop 214. When the propulsion throttle 46 is in its full line or stop position (as shown in FIG. 6), the curved camming groove 220 of the control links 196 remains between the cylindrical followers 226 and 228.

Pivotal movement of the propulsion throttle 46 in one direction causes the second Bowden cable 194 to move the control link clockwise about the pivot axis 208 at the point of connection between the control link and the drag lever 206. Thus, one cylindrical follower 226 is received within the curved camming groove 220.

At this point, pivotal movement of the memory throttle 51 moves the drag link 206 clockwise about its pivot point 210, to thereby drag the control link 196 and cause pivotal movement of the follower lever 222 in a clockwise direction. This movement in turn pivots the swashplate control handle 108, by means of the third Bowden cable 198, to cause rotation of the eccentric means in one direction, as previously described.

When the direction of propulsion is to be reversed, the memory throttle 51 is brought back to its full line, or stop position. Through the drag lever 206, the control link 196 causes the follower lever 222 to bring the control handle 108 of the pump 42 to its neutral position, thereby dynamically and positively braking the eccentric means.

The propulsion throttle 46 is now pivoted in an opposite direction which causes the control link 196 to pivot counterclockwise about the axis 208 as viewed in FIG. 7. The second cylindrical follower 228 is now received within the camming groove 220. Pivotal motion of the memory throttle 51, which causes dragging of the control link 196 through the drag lever 206, now moves the follower lever 222 in a counterclockwise direction. Therefore, the control handle 108 of the pump 42 is pivoted in an opposite direction so as to reverse the direction of rotation of the eccentric means and correlate that direction with the direction of translation of the vehicle.

It will be appreciated that if the direction of propulsion of the vehicle is reversed without bringing the eccentric means to a stop, the control link 196 will still be pivoted about its displaced axis 208, and the curved camming groove 202 will ride over the follower projection,

thereby leaving the follower lever in its pivoted position. Thus, to reverse the direction of rotation of the eccentric means, it will be necessary to bring the memory throttle back to its stop position. This will cause one of the flat end faces 230 and 231 of the camming head 218 to move the follower lever to its neutral position, and then the correct cylindrical follower projection will move into the slot as the control link continues to pivot about its axis 208 under the action of the Bowden cable 194.

In order to avoid the necessity for an operator having to continuously select the proper pivotal position of the eccentric control throttle when bringing the eccentric means into operation, the eccentric control throttle is constructed as a memory throttle, as best seen in FIG. 8. This memory throttle 51 is provided with a longitudinally extending slot 232 in which one end of an adjustable link 233 (shown in phantom in FIG. 8) is constrained for slidable movement.

The other end of the adjustable link 233 is constrained for slidable movement in a longitudinally extending slot 234 in a bracket 236. When the memory throttle 51 is in its fully pivoted position (FIG. 8), the link constraining slots 232 and 234 are generally aligned. Pivotal movement of the throttle beyond this point is prevented by a suitable over center lock (not shown).

Pivotal movement of the memory throttle 51 about an axis 238 on the bracket 236 moves the link 233 within the slots 232 and 234. The fourth Bowden cable 216 is attached to the bracket end of the adjustable link 233 so as to control movement of the drag lever 206 of the control means 48.

In order that the memory throttle 51 need only be moved between its stop and a fully pivoted position once a preferred rotational speed of the eccentric means has been determined, the position of the adjustable link 233 within the throttle slot 232 is controlled by a micrometer head 240. With the micrometer head properly adjusted, a full throw of the memory throttle 51 will provide a proper movement of the pump control handle 108 through the linkage of the automatic control means 48. This movement of the control handle 108 moves the swash-plate of the pump to the desired angle corresponding to the selected speed of eccentric means.

It will be appreciated that the control means 48 automatically correlates the direction of tilt of the swash-plate (and therefore the direction of rotation of the eccentric means) with the direction of propulsion of the vehicle.

Operation of the self-propelled vibration compacting machine of the present invention may now be described. The operator selects the direction and speed of machine movement by proper positioning of the propulsion control throttle 46. The machine may be maneuvered from the straight line path by control of the steering wheel 28 which causes the piston and cylinder assemblies 32 and 34 on the tractor frame 10 to pivot the roller support frame 22 by a selected amount about the generally vertical axis 20.

With the machine moving in the forward direction and with the eccentric means control throttle 51 moved to a pivoted position, the eccentric means rotates in an angular direction tending to induce rotation of the roller in the same direction of roller rotation induced by propulsion of the machine. In this way, uniformity in compaction of the asphalt or other surface is promoted and tractive effort necessary to propel the vehicle is reduced rather than increased by rotation of the eccentric means.

Before reversing the direction of the vibratory compacting machine, the rotating eccentric means is stopped by moving the eccentric means control throttle 51 to its stop position (full line as shown in FIG. 6). The tight, closed-loop fluid circuit between the pump 42 and the motor 40 of the vibrator transmission causes immediate, positive dynamic braking of the eccentric means. With a properly sized transmission of the type previously de-

scribed, and a resonance speed peak of about 600 r.p.m., the rotating eccentric means was positively decelerated through a resonance range of about 240 r.p.m. from an initial speed of about 15000 r.p.m., in about three revolutions thereof. The positively braked eccentric means is thus moved through the resonance range in about one-third of a second. This may be particularly attributed to the fact that the motor 40 has a substantially constant torque over a wide speed range.

When the direction of machine propulsion is reversed, and the eccentric means control throttle 51 is pivoted to operating position, the automatic direction control means 48 automatically reverses the direction of rotation of the eccentrics 56.

When the memory throttle 51 is employed, once the memory system is set, as previously described, it is only necessary for the operator to move the throttle 51 between full speed and stop positions, immediately before and during translation direction changes. The speed of the eccentric means will be controlled by the memory.

It will be appreciated that the eccentric speed passes through the resonant range during acceleration in substantially the same time as it does during deceleration.

SUMMARY OF ADVANTAGES

Thus it will be seen that in following the present invention, an improved vibrating machine is provided.

Particularly significant is the provision for positive braking of a rotatable eccentric means.

Also of importance is the reversible driving of an eccentric means mounted for rotation about the axis of the tamping roller. With such an arrangement, tractive effort necessary for machine propulsion is minimized, and skipping or bumping of the roller as a result of rotational forces on the roller generated by the rotating eccentric means is eliminated.

Of related importance is the automatic control that correlates the direction of rotation of the eccentric with the direction of translation of the machine without operator intervention.

Moreover, the hydrostatic transmission, with a closed-loop, tight circuit between the variable displacement pump and the fixed displacement motor, eliminates the need for clutches between the transmission and the eccentric and the need for valving in the system such as that required in hydrodynamic circuits. This feature in combination with the rotatable eccentric means provides the rapid response necessary for minimizing problems associated with resonance.

Although the invention has been described with reference to one preferred illustrated embodiment, it will be appreciated by those skilled in the art that additions, modifications, substitutions, deletions and other changes not specifically described may be made which fall within the spirit of the invention.

What is claimed is:

1. In a vibratory compacter of the type including a frame, a freely rotatable compacting roller resiliently mounted on the frame, and eccentric means rotatable about the roller axis for vibrating the compacting roller, the improvement comprising:

reversible and variable speed hydrostatic transmission means, continuously coupled to said eccentric means and comprised of a pump and motor in closed loop fluid circuit, for selectively rotatably driving said eccentric means in each of two directions of rotation at a speed greater than the range of speeds at which resonance exists between said frame and said compacting roller, and for rapidly, positively and dynamically braking said eccentric means through the range of speeds at which resonance exists between said frame and said compacting roller.

2. The improvement according to claim 1 wherein said hydrostatic transmission means comprises:

a reversible variable displacement pump,

a fixed displacement motor, said fixed displacement motor being fluid coupled to said variable displacement pump by a closed loop, tight fluid circuit.

3. In a translatable vibratory compacter of the type including a resiliently mounted and freely rotatable compacting roller, and eccentric means rotatable about the roller axis for vibrating the compacting roller, the improvement comprising:

means for selectively rotatably driving said eccentric means in each of two directions of rotation, and for positively braking said eccentric means, and control means responsive to the direction of translation of said vibratory compacter and connected to said means for selectively driving and positively braking said eccentric means, for correlating the direction of rotation of said eccentric means with the direction of translation of said vibratory compacter.

4. A vibratory compacter comprising:

a translatable support frame;

a compacting roller resiliently mounted on said support frame for compacting engagement with the ground,

rotatable eccentric means for vibrating said compacting roller, and

variable speed hydrostatic transmission means, comprised of a pump and motor in closed loop fluid circuit, for rotating said eccentric means at a speed greater than the range of speeds at which resonance exists between said frame and said compacting roller and for rapidly, positively and dynamically braking said rotatable eccentric means through the range of speeds at which resonance exists between said frame and said compacting roller.

5. The vibratory compacter according to claim 4 wherein said hydrostatic transmission means comprises:

a variable displacement pump,

a fixed displacement motor, said fixed displacement motor being fluid coupled to said variable displacement pump by a closed loop, tight fluid circuit, and being continuously connected to said rotatable eccentric means.

6. A vibratory compacter according to claim 4 wherein: said rotatable eccentric means is selectively rotatable in each of two angular directions about the axis of said roller, and

said hydrostatic transmission means comprises means for selectively rotating said rotatable eccentric means in each of said two angular directions correlatable with the direction of translation of the frame.

7. A translatable vibratory compacter comprising:

a support frame,

a compacting roller resiliently mounted on said support frame for compacting engagement with the ground, rotatable, eccentric means for vibrating said compacting roller, and selectively rotatable in each of two angular directions about the axis of said roller,

hydrostatic means for selectively rotating said rotatable eccentric means in each of said two angular directions at a speed greater than the range of speeds at which resonance exists between said frame and said compacting roller, and for positively braking said rotatable eccentric means through the range of speeds at which resonance exists between said frame and said compacting roller and said hydrostatic means comprising a hydrostatic transmission including

a variable displacement pump,

a fixed displacement motor, said fixed displacement motor being fluid coupled to said variable displacement pump by a closed loop, tight fluid circuit, and being continuously connected to said rotating eccentric means, and

control means responsive to the direction of translation of said vibratory compacter, and connected to said means for rotating said eccentric means, for correlating the direction of rotation of said eccentric means

with the direction of translation of said vibratory compacter.

8. A vibratory compacter comprising:

a frame,

means supporting said frame for selective ground traversing movement in forward and reverse directions,

a compacting roller mounted on said support frame for compacting engagement with the ground,

rotatable, eccentric means, mounted for rotation about the axis of said compacting roller, for vibrating said compacting roller, said rotatable eccentric means being selectively rotatable in each of two angular directions,

means for selectively propelling said frame in the forward and reverse directions, and

means, responsive to the direction of translation of said frame, for selectively rotating said eccentric means in each of said two angular directions in correlation with the direction of translation of said frame.

9. A vibratory compacter according to claim 8 wherein said means for selectively rotating said eccentric means includes:

control linkage means, operatively connected to said means for selectively propelling said frame in forward and reverse directions, for automatically correlating the direction of rotation of said eccentric means with the direction of translation of said frame.

10. A vibratory compacter according to claim 8 wherein: said means for selectively rotating said eccentric means comprises a hydrostatic transmission including

a reversible, variable displacement pump,

a fixed displacement motor, said fixed displacement motor being fluid coupled to said variable displacement pump by a closed loop, tight fluid circuit, and being continuously coupled to said eccentric means, and

means for reversing said pump to reverse the direction of rotation of said eccentric means.

11. A vibratory compacter according to claim 8 including:

means for positively braking said rotatable eccentric means.

12. A vibratory compacter according to claim 11 wherein:

said means for selectively rotating said eccentric means, and said means for positively braking said eccentric means together comprise a single hydrostatic transmission including

a reversible, variable displacement pump,

a fixed displacement motor, said fixed displacement motor being fluid coupled to said variable displacement pump by a closed-loop, tight fluid circuit, and being continuously coupled to said rotatable eccentric means.

13. A vibratory compacter comprising:

a frame,

means supporting said frame for selective ground traversing movement in forward and reverse directions,

a compacting roller mounted on said frame for compacting engagement with the ground,

rotatable eccentric means, mounted for rotation about the axis of said compacting roller, for vibrating said compacting roller at a rate independent of frame propulsion rate, said rotatable eccentric means being selectively rotatable in each of two angular directions,

means for selectively propelling said frame in the forward and reverse directions and rotating said roller in opposite directions during frame propulsion in forward and reverse directions, and

means for selectively rotating said eccentric means in each of said two angular directions correlatable with the direction of translation of said frame,

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said means for selectively rotating said eccentric means in each of said two angular directions correlatable with the direction of translation of said frame including an adjustable lever having a neutral position at which no rotation is imparted to said eccentric means and active positions on opposite sides of said neutral position,

said lever being movable to an active position on one side of said neutral position for rotating said eccentric means in a first direction tending to induce compacting roller rotation in the same direction as that produced during a forward movement of said frame, and said lever being movable to an active position on the opposite side of said neutral position for rotating said eccentric means in a second direction tending to induce compacting roller rotation in the same direction as that produced during a reverse movement of said frame.

14. A vibratory compacter comprising:

a frame,

means supporting said frame for selective ground traversing movement in forward and reverse directions,

a compacting roller mounted on said frame for compacting engagement with the ground,

rotatable, eccentric means, mounted for rotation about the axis of said compacting roller, for vibrating said compacting roller, said rotatable eccentric means being selectively rotatable in each of two angular directions,

means for selectively propelling said frame in the forward and reverse directions, and

means for selectively rotating said eccentric means in each of said two angular directions correlatable with the direction of translation of said frame,

said means for selectively rotating said eccentric means in each of said two angular directions correlatable with the direction of translation of said frame including adjustable memory throttle means for maintaining the speed of rotation of said eccentric means

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substantially identical in each of said two angular directions.

15. A method of compacting a road surface with a vibratory compacter of the type including a propellable frame on which a freely rotatable compacting roller is mounted for vibratory engagement with the ground, and further including an eccentric means, mounted for two-directional rotation about the axis of the roller, for vibrating the roller at a rate independent of frame propulsion rate, the method comprising the steps of:

propelling the frame and the roller in a first translating direction over the road surface and thereby causing the roller to rotate in a clockwise direction, and simultaneously rotating the eccentric means in a first angular direction tending to induce rotation of the roller in a clockwise direction; and

subsequently propelling the frame and the roller in an opposite translating direction and thereby causing the roller to rotate in a counterclockwise direction, and simultaneously rotating the eccentric means in a second angular direction tending to induce roller rotation in a counterclockwise direction.

16. The method according to claim 15 wherein the roller is resiliently mounted on the frame, the method including the step of:

dynamically braking the eccentric means prior to changing the direction of rotation of the eccentric means and the direction of translation of the frame and roller.

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JACOB L. NACKENOFF, Primary Examiner