

[54] **GROUND COMPACTING APPARATUS**

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[58] Field of Search **94/50, 50 V**

[56]

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[57]

ABSTRACT

The roller of an earth compactor of the vibratory roller type is vibrated by revolving an eccentric mass about the roller axis. The eccentric mass is carried by a hollow shaft rotatable in bearings at end portions of the roller. A slender elongated steel drive shaft extends into one end of the hollow shaft. A hydraulic motor is detachably mounted for vibration with the roller and is connected by a spline connection to one end portion of the drive shaft. The other end portion of the drive shaft is rigidly connected to an interior portion of the hollow shaft. The length and flexibility of the drive shaft permit it to twist and flex so as to accommodate the substantial deflections and torque variations which occur as the eccentric mass is revolved to vibrate the roller.

7 Claims, 2 Drawing Figures

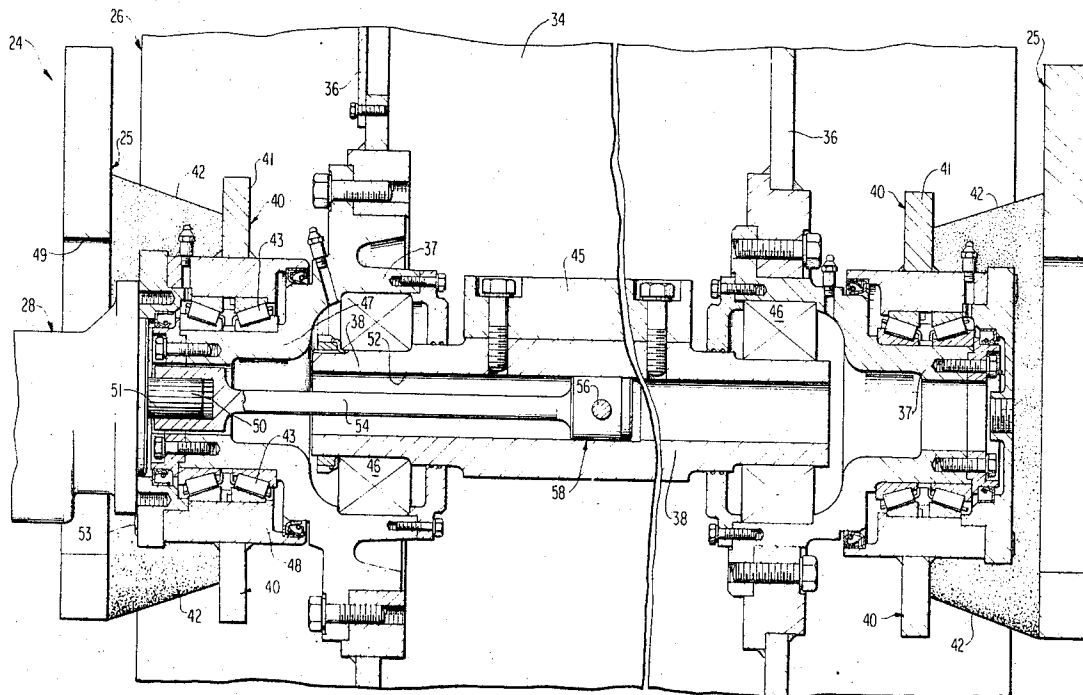
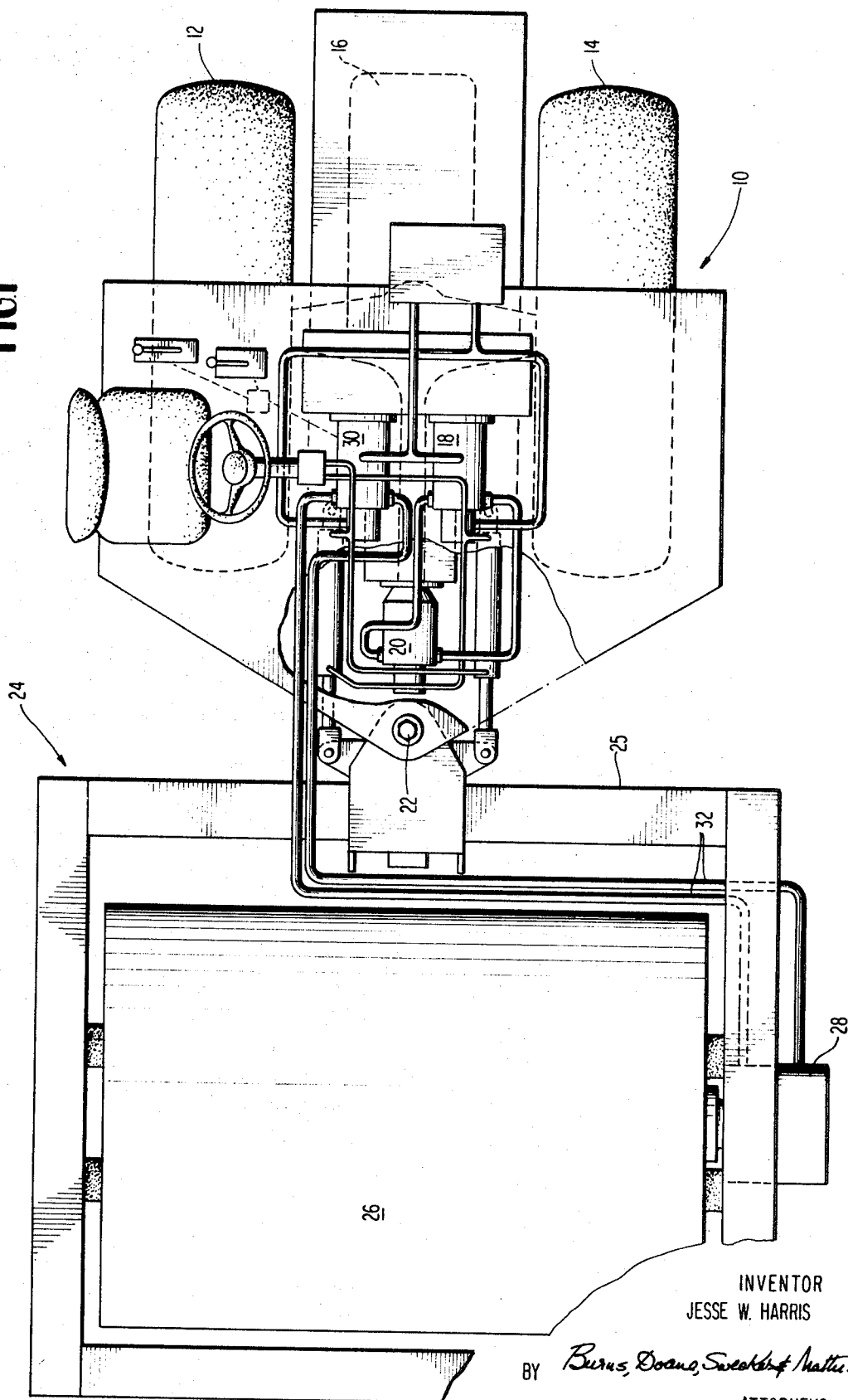


FIG 1



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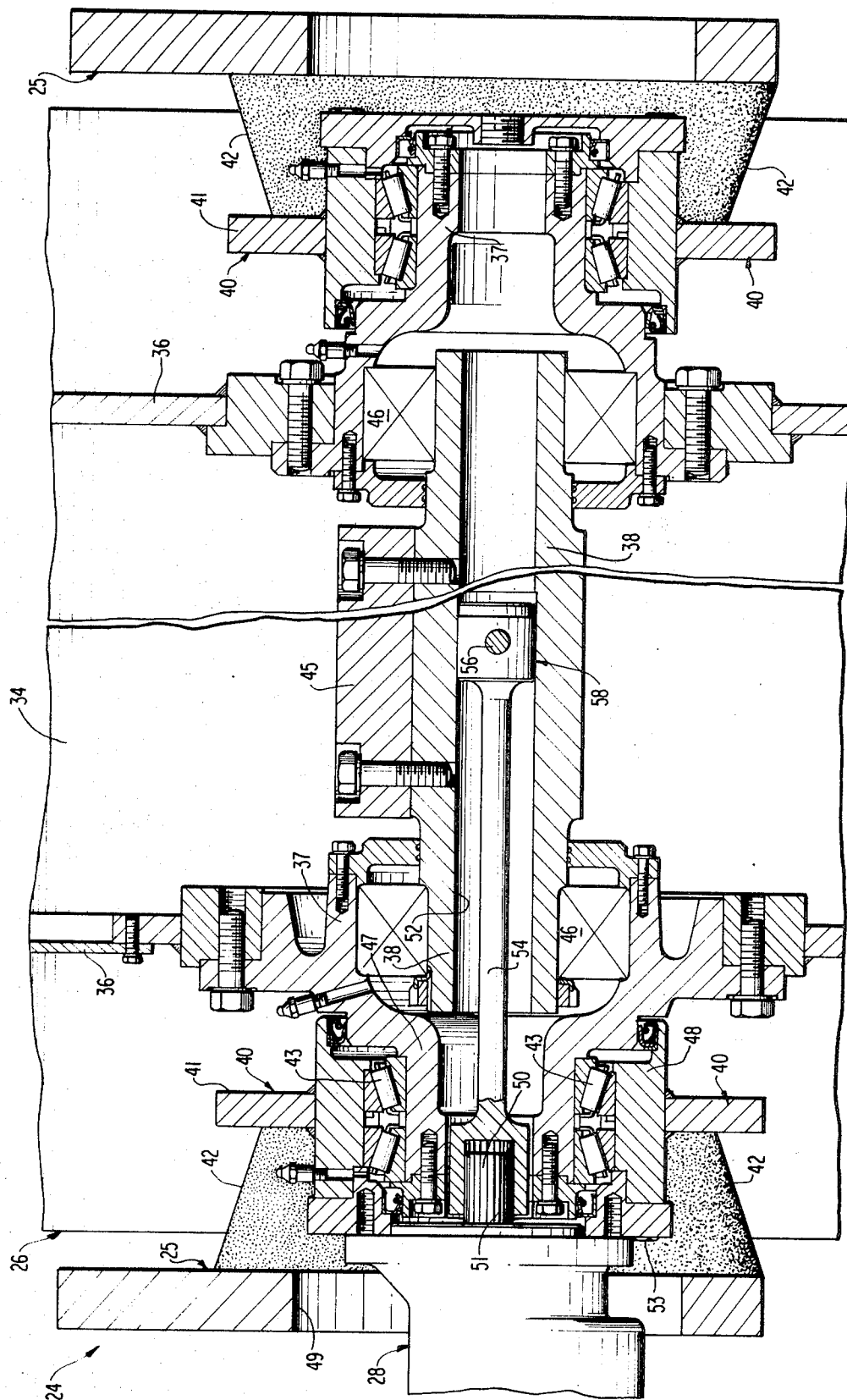


FIG 2

GROUND COMPACTING APPARATUS

BACKGROUND OF THE INVENTION

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

The earth compacting industry has long recognized the general desirability of vibratory roller machines for many compaction tasks. Properly constructed and operated machines of this type can be employed effectively to compact dirt, sand, composition materials such as asphalt, and various other surface materials encountered in the construction of roads and the like.

In a preferred type of vibratory roller machine, vibration is caused by eccentric means within the roller and driven rapidly about the roller axis. As the eccentric revolves about the roller axis it exerts forces tending to lift the roller from the ground and then to thrust the roller downwardly again against the ground. Although such machines are capable of producing good compaction, mechanical problems have been encountered in connection with the drives for the eccentrics.

These machines have employed both "direct" and "indirect" drive systems for the eccentrics. In the direct drive systems, the motor supplying driving power for rotating the eccentric is mounted to vibrate with the roller and is directly connected by a coupling unit to the shaft carrying the eccentric. In the indirect drive systems, the motor does not vibrate with the roller, and the drive train by which the motor is coupled to the eccentric shaft must be capable of accommodating the movements associated with the vibration of the roller relative to the drive motor. An example of a satisfactory drive of the indirect type is disclosed in Martin U.S. Pat. No. 3,411,420.

The present invention is more particularly concerned with drives of the direct type, where much difficulty has been encountered in providing a satisfactory coupling unit for connecting a hydraulic motor to the eccentric shaft. This difficulty stems from some very unusual force and deflection patterns which make stock couplings unsuitable.

Deflection of the shaft carrying the eccentric results from the centrifugal force associated with the revolving eccentric. When the shaft is at rest, it is coaxial with the roller and an end thereof might be coupled directly to a parallel output shaft on a hydraulic drive motor. However, when the eccentric is brought up to operating speed, typically twenty to thirty cycles per second, centrifugal force causes the mid-portion of the shaft to bow outwardly in the direction of the eccentric. This tends to displace the ends of the shaft in opposite directions and also to incline the end portions of the shaft with respect to the axis of the roller, so that misalignment of the motor and the driven eccentric shaft is a normal condition in this harsh environment. Many couplings cannot accommodate such misalignment.

The torque criteria also are distinctive. In these vibratory compactors the eccentric drive motors supply about 20 to about 50 horsepower typically, and this energy is dissipated as work in compacting the ground and in lifting the roller for the next compacting stroke. Characteristically, the work input to the system consists of accelerating the eccentric back to the desired speed after it is slowed by extraction of energy in these two parts of the cycle. These speed variations at the

shaft should not, however, also exist at the drive motor because such would produce an undesirable torque variation pattern. A large torque increase feeding back to the hydraulic drive motor would raise pressure and cause "pulsing" of hoses, motor, pump and prime mover. On the other hand, the use of a soft elastomeric coupling for smoothing out the speed variations at the eccentric bearing shaft and minimizing feedback to the drive motor gives rise to overheating difficulties and coupling unit failure.

SUMMARY OF THE INVENTION

A principal object of the present invention is to overcome the difficulties noted above and to provide a simple but reliable drive for coupling a drive motor to an eccentric shaft of a vibratory compactor.

A more particular object of the invention is to directly couple together a hydraulic drive motor and the eccentric shaft of a vibratory roller with a coupling which will maintain chatter-free drive contact areas, will absorb displacements and torque variations, and will not heat up excessively.

These and other objects are accomplished in accordance with the invention through the provision of a flexible, elongated, steel drive shaft for directly coupling an eccentric shaft to a hydraulic drive motor. The eccentric shaft is hollow and is mounted in bearings coaxial with a vibratory roller. The motor is mounted for vibration with the roller and preferably is coaxial therewith adjacent one end of the eccentric shaft. The metal drive shaft is connected at one end to the motor, extends into the adjacent end of the hollow eccentric shaft, and is fastened to an interior portion of the eccentric shaft.

With this arrangement, the elongated steel drive shaft provides not only sufficient strength to withstand the loads generated in the system but also the flexibility required for accommodating torque variations and eccentric shaft deflections. It is preferred that the main body of the drive shaft be slender as compared with the opening in the hollow eccentric shaft so as to provide an air space surrounding the drive shaft to facilitate the dissipation of heat generated by the twisting of one end of the drive shaft relative to the other in response to cyclical speed variations at the eccentric shaft.

A more complete understanding of these and other features and advantages of the invention will be gained from a consideration of the following detailed description of a preferred embodiment illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic plan view of a ground compacting machine of the self-propelled vibratory roller type embodying the invention.

FIG. 2 is a partial cross-sectional view taken generally along the axis of the vibratory roller of the machine of FIG. 1 and illustrating in detail the novel eccentric drive of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a compactor machine is there shown as including a tractor frame 10 and spaced parallel wheels 12 and 14 supporting the frame for ground traversing movement. The wheels are driven by an internal combustion engine 16 acting preferably through

a hydrostatic transmission schematically illustrated as including a hydraulic pump 18 and a motor 20.

On the forward end of the tractor frame 10 a vibratory ground compacting roller apparatus 24 is provided. Ground, in the context of this application, may include gravel, asphalt, sand, or any other material which may be compacted by a machine of this sort. The apparatus 24 includes a frame means 25 mounted for pivotal movements about a vertical axis at pin 22 so that the machine may be steered as the wheels 12 and 14 are driven. The roller support frame 25 resiliently supports a freely rotatable ground contacting roller 26. The roller 26 is provided with an eccentric mass therein for imparting vibratory action and will be hereinafter more fully described with reference to FIG. 2. A hydraulic drive motor 28, for rotating the eccentric means, is mounted for vibration with the roller 26 and may be driven by an engine driven pump 30 carried by the tractor frame 10 and coupled to the motor 28 by hose means 32.

Referring now more particularly to FIG. 2, it will be seen that the roller 26 includes a cylindrical shell 34 which defines the outer ground contacting periphery of the roller 26. Two transversely extending closures 36 support the shell 34 and are disposed at opposite end portions of the shell. These closures are spaced inwardly of the outer edges of the roller shell 34 and are provided with bearing receiving portions 37.

The frame means 25 includes portions thereof disposed opposite the ends of the roller 26 and mounting means 40 are interposed between these portions of the frame and the adjacent roller end closures 36. Each of the mounting means 40 includes a suspension beam member 41 connected to the adjacent frame portion by elastomeric bodies 42 which permit the beam member 41 to vibrate relative to the frame. The suspension beam 41 in turn supports the roller 26 for rotation by means of bearings 43 interposed between hub members 47 at the ends of the roller 26 and sleeves 48 fixed in place on the beams 41.

It can be appreciated that, during a compacting operation, there may be substantial relative movement between the roller 26 and the horizontally traveling frame 25. The resilient means 42 is provided to absorb much of the shock and to prevent interference between the frame 25 and the roller 26.

A hollow shaft 38 carrying an eccentric 45 is supported for rotation within the bearing receiving portions 37 of the roller 26 by means of bearings 46. These bearings preferably are of the spherical bearing type, but other suitable types may be used if desired. It can be appreciated that as the shaft means 38 is rotated, the eccentric 45 develops vibratory oscillations in the resiliently mounted, independently rotatable roller 26.

The hydraulic eccentric drive motor 23 is received loosely within an opening 49 in the adjacent portion of the frame 25 and is secured to an end portion of the mounting means 40 by bolts 53 screwed into the adjacent sleeve 48, or by any other suitable means. This drive motor 28 is provided with a rotary power output element 50 which is aligned with the central axis of the roller 26 and which protrudes into a central opening in the adjacent roller hub portion 47.

The rotary output element 50 of the motor is connected to the eccentric shaft means 38 by a flexible, elongated, steel drive shaft 54. This drive shaft is enlarged at its ends, and the outer end is hollow for re-

ceiving therewithin the end of the rotary output element 50 of the motor. Interengaging spline means 51 on the motor output element 50 and the outer end portion of the drive shaft 54 lock these parts together for rotation. From the motor, the drive shaft 54 extends axially through the hub portion 47 of the roller and within the opening 52 in the hollow eccentric shaft 38. An enlarged inner end 58 of the drive shaft 54 is secured within the opening 52 by means of a cross pin 56.

During rotation of the shaft 38, relatively large centrifugal forces are generated as the eccentric 45 revolves about the roller axis. This causes the center of the shaft 38 to bow in the direction of the eccentric mass 45 and the ends of the shaft incline in the opposite direction. Although these deflections are substantial, the long steel drive shaft 54 flexes to accommodate them without imposing excessive stresses on any of the components.

The steel shaft 54 also maintains a relatively constant driving force on the shaft 38 and the motor 28 by absorbing the torque "wind up" experienced in vibratory rollers by reason of the fact that energy dissipation occurs primarily over short time intervals while energy input occurs at a substantially constant rate. The present invention is well suited to such patterns because the ends of the elongated steel shaft 54 may twist relative to each other to smooth out the speed variations without generating excessive loads.

It is noted also that a large air space surrounds the slender central portion of the drive shaft 54. As the rapidly moving shaft surface contacts the air, heat generated within the flexible shaft 54 is readily dissipated into the air and overheating is precluded. The motor 28, therefore, runs at a relatively constant speed avoiding power surges or other damaging effects of uneven driving.

Although the invention has been described with reference to an embodiment illustrated in the drawings, it will be appreciated by those skilled in the art that additions, modifications, substitutions, deletions and other changes not specifically described herein may be made without departing from the spirit of the invention. It is intended therefore that the foregoing be considered as exemplary only and that the scope of the invention be ascertained from the following claims.

What is claimed is:

1. In ground compacting apparatus of the type having a rotatable vibratory roller for contacting the ground to be compacted, eccentric means within said roller, and motor means for driving said eccentric means to vibrate said roller, the improvement comprising:

an eccentric support shaft supporting said eccentric means within said roller and having an opening extending axially inwardly from at least one end thereof;

means for rotatably mounting said eccentric support shaft within said roller; and

a flexible metal drive shaft of smaller cross section than said axial opening in said eccentric support shaft; said flexible drive shaft being connected at one end portion thereof to said motor means, extending freely into said axial opening in said eccentric support shaft in spaced relation to the walls of said opening, and being connected at an opposite end portion thereof to said eccentric support shaft.

2. A ground compactor of the vibratory roller type comprising:

a ground contacting roller,
 means mounting said roller for rotation about its axis
 and for vibration relative to the ground,
 a hollow shaft carried by said roller for rotation about
 the axis of said roller, said shaft having an eccentric
 mass thereon within said roller so that upon rota-
 tion of said hollow shaft said mass revolves about
 the axis of said roller to vibrate said roller relative
 to the ground,
 motor means mounted for vibratory movement with
 said roller,
 a rotary output element on said motor means coaxial
 with and facing an end of said hollow shaft, and an
 elongated, slender, flexible, metal drive shaft ex-
 tending within said hollow shaft, said drive shaft
 being connected at one end thereof to said output
 element on said motor means and being connected
 to said hollow shaft at a location spaced from the
 ends of said hollow shaft, the diameter of said
 metal drive shaft being so small as to space the ex-
 terior surface of said metal drive shaft from the in-
 ternal wall of said hollow shaft except at said loca-
 tion when said drive shaft is connected to said hol-
 low shaft, whereby said elongated metal drive shaft
 transmits rotary motion from said motor means to
 said hollow shaft and flexes to accommodate dis-
 placements and torque variations generated during
 revolution of said eccentric mass and vibration of
 said roller.
 3. In vibratory roller ground compacting apparatus of
 the type having a ground contacting roller which in-
 cludes a cylindrical shell and transversely extending
 closures at opposite end portions of the shell having
 bearing receiving portions thereon, frame means mov-
 able over the surface to be compacted having portions
 opposite the ends of said roller and having mounting
 means including resilient means connected to said por-
 tions of said frame means for vibrationally suspending
 said closures of said roller on said frame means, shaft
 means extending generally axially of said roller and
 having at least one eccentric mass thereon between
 said closures of said roller, bearing means for rotatably
 mounting opposite end portions of said shaft means on
 said bearing receiving portions of said closures and an
 eccentric drive carried by said mounting means and
 having a rotary output element directed toward an end
 of said shaft means, the improvement comprising:
 means defining an opening extending axially of said
 shaft means from the end thereof nearest said ro-
 tary output element;
 a metal drive shaft rigidly coupled at its ends respec-
 tively to said shaft means and said rotary power
 output element, said drive shaft having a smaller
 cross section than said opening in said shaft means
 and extending along said opening in spaced rela-

tion to the walls thereof at least as far as said adja-
 cent bearing means for said shaft means and being
 flexible to absorb deflection and shock loads devel-
 oped as said shaft means is rotated to move said ec-
 centric mass about the axis thereof.
 4. In ground compacting apparatus of the type having
 a ground contacting roller which includes a cylindrical
 shell and transversely extending closures at opposite
 end portions of the shell, frame means movable over
 the surface to be compacted and having portions oppo-
 site the ends of said roller, a mounting unit between
 each of said frame portions and said roller, means resili-
 ently connecting each of said mounting units to one of
 said frame portions for vibration relative thereto,
 means rotatably connecting each of said mounting
 units to one of said closures of said roller to permit ro-
 tation of said roller relative to said mounting units,
 shaft means extending generally axially of said roller
 and having at least one eccentric mass thereon between
 said closures of said roller, bearing means at opposite
 end portions of said shaft means for supporting said
 shaft means within said roller, and an eccentric drive
 motor carried by one of said mounting units and having
 a rotary output element directed toward an end of said
 shaft means, the improvement comprising:
 means defining an opening extending axially of said
 shaft means from the end thereof nearest said
 motor to a location beyond the adjacent one of said
 bearing means; and
 a flexible metal drive shaft rigidly connected to said
 rotary output element of said motor and extending
 into said opening in spaced relation to the walls of
 said opening, an inner end portion of said metal
 drive shaft being rigidly connected to said shaft
 means at a location between said bearing means for
 transmitting rotating motion from said motor out-
 put element to said shaft means.
 5. The apparatus of claim 4, wherein said motor is re-
 movably connected to said one of said mounting units
 and wherein a spline-type connection is employed be-
 tween said drive shaft and said rotary output element
 of said motor.
 6. The apparatus of claim 4, wherein said motor is a
 hydraulic motor and is a part of a hydraulic system, and
 wherein said drive shaft is sufficiently flexible to permit
 a limited amount of twist of the ends thereof relative to
 each other to accommodate torque variations and min-
 imize surges in the hydraulic system.
 7. The apparatus of claim 4, wherein said bearing
 means includes a spherical bearing at each end portion
 of said hollow shaft to permit flexing of said hollow
 shaft during revolution of said eccentric mass, and
 wherein said drive shaft flexes to accommodate deflec-
 tions of said hollow shaft relative to said motor.

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