

[54] ECCENTRIC SYSTEM FOR VIBRATORY EARTH COMPACTOR

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259/DIG. 42

[51] Int. Cl. B06b 1/16

[58] Field of Search. 74/87, 61; 94/50 V, 48;
209/366.5, 367; 259/DIG. 42

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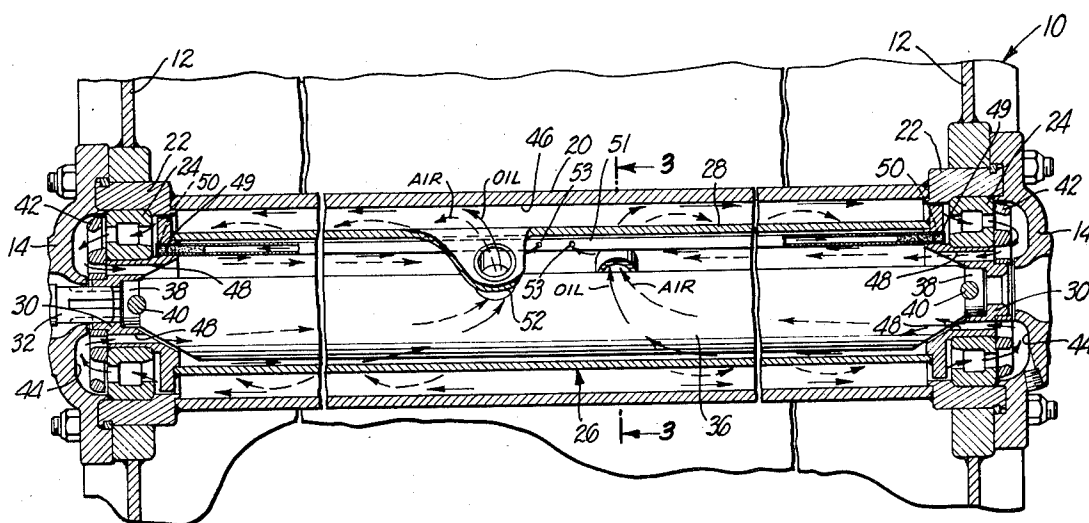
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[57] ABSTRACT

An eccentric system for a vibratory apparatus, such as an earth compactor, comprising a tube having end closures, bearings respectively supporting the end closures for rotation of the end closures and the tube about the axis of the tube, and an eccentric bar within and extending longitudinally of and spaced radially inwardly from the tube, the eccentric bar having ends coaxial with the tube and respectively carried by the end closures of the tube. The tube, its end closures and the eccentric bar constitute an eccentric shaft which, together with its bearings, is enclosed by an outer housing. Impellers at the ends of and rotatable with the eccentric shaft circulate a lubricant, such as oil, between the interior of the tube and the outer housing by way of the bearings, thereby lubricating and cooling the bearings continuously. Air in the structure is also circulated through the bearings by the impellers for cooling purposes.

10 Claims, 5 Drawing Figures



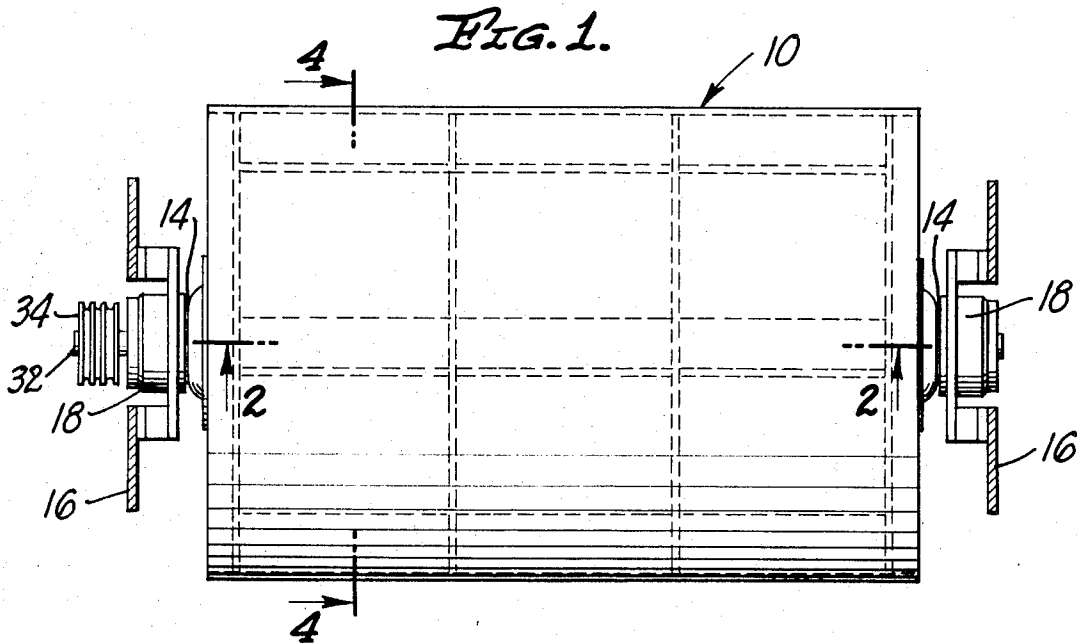
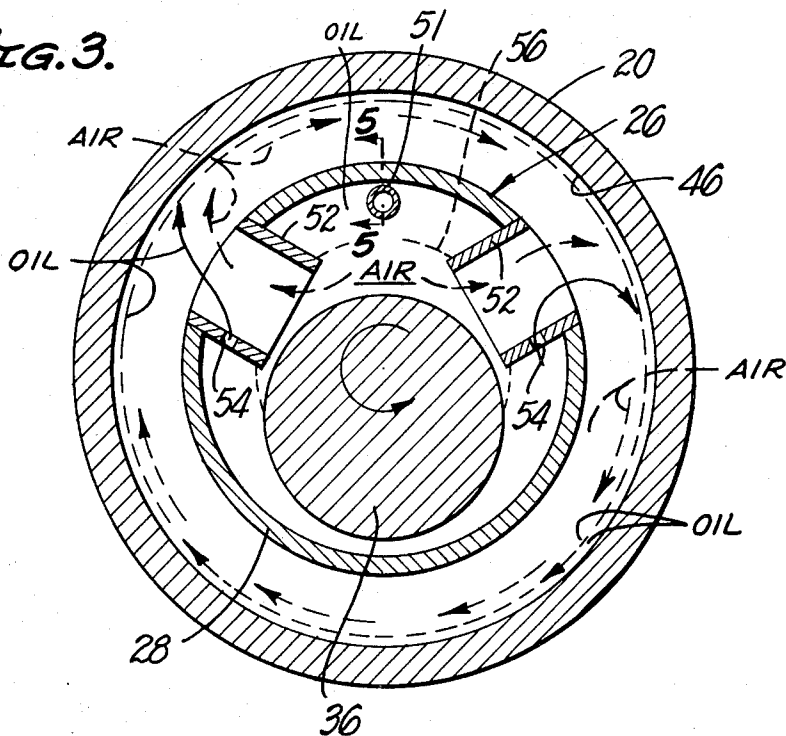


FIG. 3.



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FIG. 2.

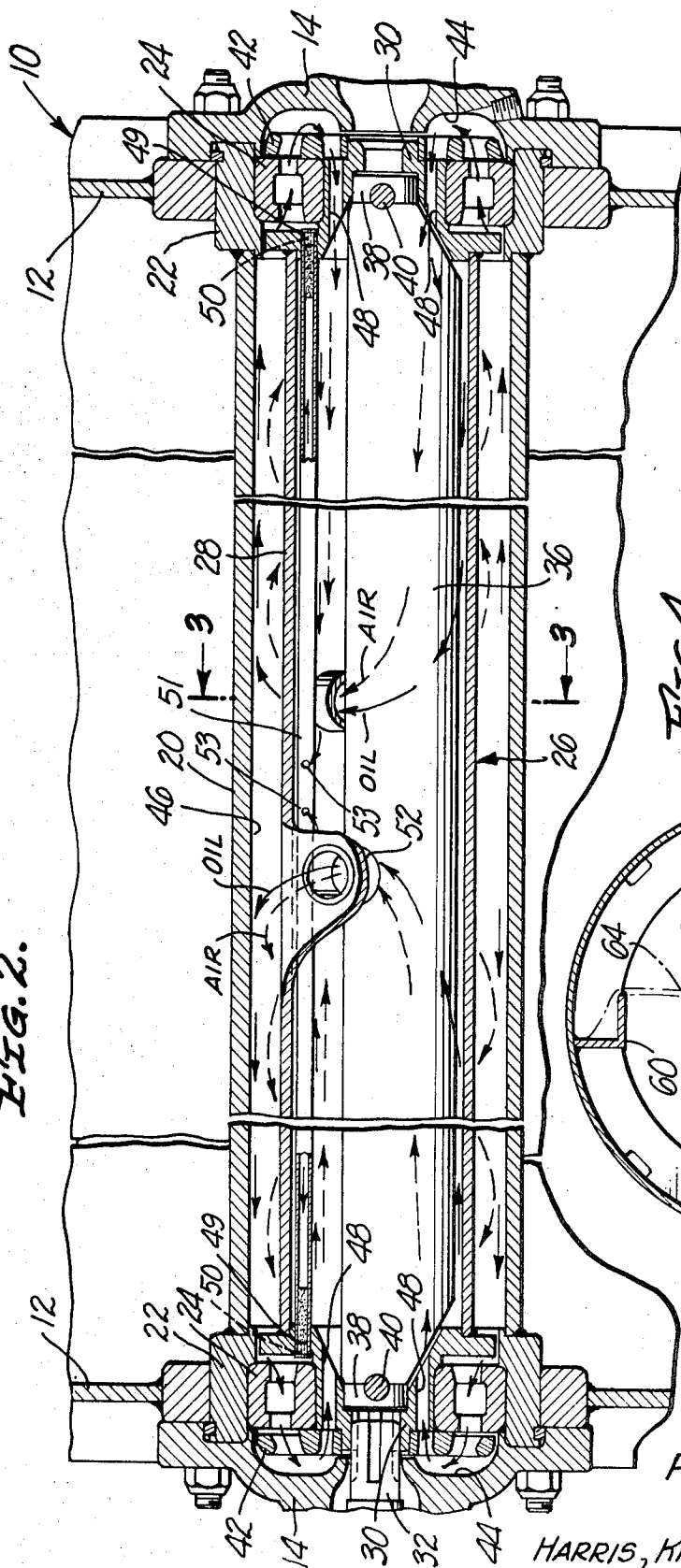


FIG. 4.

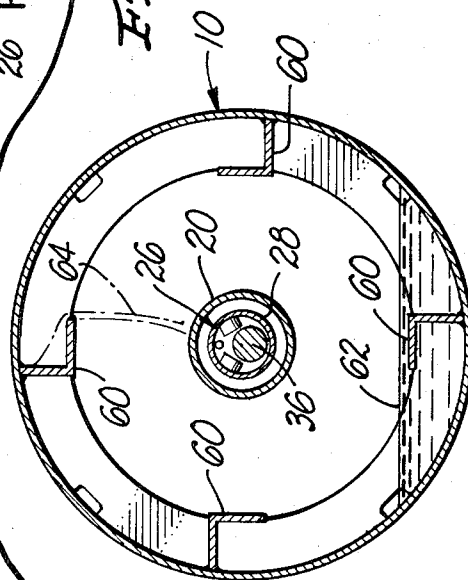
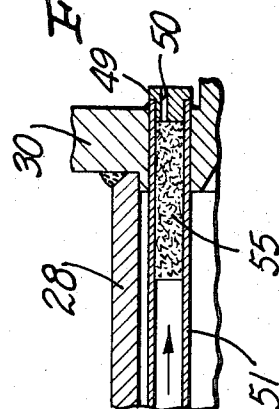


FIG. 5.



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ECCENTRIC SYSTEM FOR VIBRATORY EARTH COMPACTOR

BACKGROUND OF INVENTION

The present invention relates in general to an eccentric system for inducing vibration in a vibratory apparatus. Since the invention is particularly applicable to a vibratory roller of an earth compactor, it will be considered in such connection herein as a matter of convenience. Vibrating an earth compacting roller can be an economical means of increasing compaction production by more effectively utilizing the weight of the roller. Although an asset in the sense that it increases compaction production, vibration can be a liability in equipment operation. If not properly employed, vibration tends to destroy not only the eccentric system which produces it, but the equipment to which the vibration is applied. Failure to utilize vibration properly has been responsible for much lack of efficiency and reliability in the earth compacting field.

SUMMARY AND OBJECTS OF INVENTION

With the foregoing background in mind, a primary object of the invention is to provide an eccentric system, particularly adapted for an earth compacting roller, which is capable of producing high frequencies and forces (or amplitudes) reliably at a reasonable cost.

More particularly, an important object of the invention is to provide an eccentric system which requires a very low starting effort, reduces operating power levels to a minimum, requires a minimum of maintenance, and extends bearing life to a maximum.

Still more specifically, a basic object of the invention is to provide an eccentric shaft which deflects negligibly at its supporting bearings during rotation so that the bearing wear resulting from eccentric shaft deflection in conventional systems is virtually eliminated.

Still another important object is to provide an eccentric shaft which achieves negligible deflection with a minimum moment of inertia, thereby minimizing starting effort and power requirements.

Still another important object is to provide an eccentric shaft which achieves negligible deflection at the bearings, thus allowing the application of cylindrical roller bearings rather than spherical roller bearings as are necessary for shafts which deflect. Cylindrical bearings are inherently tolerant of eccentric shaft growth relative to eccentric housing growth resulting from shaft heating and consequently do not develop the high thrust loads which are the principal cause of failures in spherical bearing applications, an important feature.

The foregoing basic objects of the invention may be achieved by providing, and another object of the invention is to provide, a composite eccentric shaft which includes: a relatively rigid or stiff tube; end closures for the tube which are supported by bearings for rotation of the tube and end closures about the axis of the tube; and a relatively flexible, low inertia, eccentric bar within and extending longitudinally of and spaced radially inwardly from the tube, this eccentric bar having ends coaxial with the tube and respectively connected to the end closures of the tube.

With the foregoing construction, the eccentric bar flexes to a considerable degree, e.g., 10 times as much as conventional eccentric shafts. However, the large forces produced by the eccentric bar are transmitted through the rigid housing end closures on a line which is very close to the center line of the bearings. The line of force is slightly offset from the center line of the bearing. The offset is calculated to produce a bending moment in the rigid housing. This moment magnitude and direction is set to nullify the bending moment resulting from the orbital motion of the rigid tube. As a result, the composite eccentric shaft of the invention is capable of producing the same eccentric forces with less than half the inertia, and only about one percent of the deflection at the bearings, of conventional eccentric shafts, which is an important feature.

Still another important object is to provide a composite eccentric shaft of the foregoing nature capable of being so mounted in an earth compacting roller or drum that drum growth in use will not detrimentally affect bearing spacing and alignment.

A further object of considerable importance is to enclose the composite eccentric shaft and its bearings in an outer housing and to provide means for circulating a lubricant through the eccentric tube, and between the eccentric tube and outer housing, as a means of providing dependable, continuous, clean and controlled flow of lubricant and air through the bearings.

More particularly, an important object in connection with the lubricating system of the invention is to provide impellers, adjacent the bearings and rotatable with the composite eccentric shaft, for circulating air as a means of circulating a small flow of lubricant in the form of lubricant droplets entrained in the air through the bearings.

Yet another object is to provide a lubricating system wherein the end closures are provided with inlet ports communicating with the impellers and through which the impellers pump the lubricant into the tube of the eccentric shaft, lubricant metering ports communicating with the bearings being provided to meter the lubricant to the bearings.

A further object is to provide air discharge ports in the tube for the discharge of air pumped into the tube through the inlet ports by the impellers, whereby air circulation throughout the eccentric shaft, its bearings and the outer housing is established for cooling purposes.

A still further object is to provide a highly reliable bearing lubrication system. This is achieved by the combined effects of the following features:

1. Lubricant cleaning—all the lubricant flows from the shaft inlet ports to the orifice duct inlets and the air vent oil discharge ports, near the center of the eccentric shaft. During the time (several minutes) required to traverse this distance, contaminants in the oil are separated out and deposited on the eccentric tube wall by high centrifugal forces (approximately 700 times gravity), thus assuring a flow of centrifugally cleaned oil to the bearings.
2. Constant and equal lubricant flow to the eccentric bearings is assured regardless of shaft attitude by the uniform distribution of lubricant along the full length of the inside of the eccentric shaft tube as a

result of the high ratio of centrifugal to gravitational force.

3. Lubricant loss rate is very low due to the housing configuration which requires only one relatively small diameter shaft seal. This seal, on the eccentric drive shaft, is very reliable since it operates at low surface speeds, is subjected to moderate temperatures, and is not subject to external abrasion due to its location inside the roll stub shaft.
4. Lubricant orifice fouling protection—orifice fouling is prevented by filter material packed upstream of the orifice in the orifice duct, by the centrifugal cleaning action which settles out contaminants near the shaft ends—well away from the orifice duct inlets, and further by locating the orifice inlet duct above the eccentric bar away from the contaminants which settle below the eccentric bar when the eccentric is idle.
5. Lubricant cooling—lubricant cooling is critical to the life of the lubricant and hence to the life of the bearings. Oil cooling capacity indirectly affects bearing heat generation since most bearing heat is produced by the lubricant itself. The lubricant flow rate and heat generation increases as lubricant viscosity drops with increase in temperature. Proper lubricant cooling capacity is thus required to maintain the lubricant at an acceptable temperature. Lubricant heat is dissipated in the following ways:
 - a. Heat is lost directly to cooler oil in the eccentric shaft as it moves from the ports at the ends to the center of the eccentric shaft.
 - b. Heat is lost by the lubricant along the full length of the eccentric shaft by radiation and air convection to the eccentric housing.
 - c. Eccentric housing heat is transmitted to the roll by radiation and conduction when not water ballasted, and by direct water convection when ballasted. When partially ballasted water is splashed over the eccentric housing by angles acting as water transports.

The foregoing objects, advantages, features and results of the present invention, together with various other objects, advantages, features and results which will be evident to those skilled in the art in the light of this disclosure, may be achieved with the exemplary embodiment illustrated in the accompanying drawings and described in detail hereinafter.

DESCRIPTION OF DRAWINGS

In the drawings:

FIG. 1 is an elevational view of a vibratory earth compacting roller equipped with the invention;

FIG. 2 is an enlarged, fragmentary longitudinal sectional view taken as indicated by the arrowed line 2—2 of FIG. 1;

FIG. 3 is a further enlarged, transverse sectional view taken as indicated by the arrowed line 3—3 of FIG. 2 of the drawings;

FIG. 4 is a transverse sectional view taken as indicated by the arrowed line 4—4 of FIG. 1; and

FIG. 5 is an enlarged fragmentary sectional view taken as indicated by the arrowed line 5—5 of FIG. 3 and duplicating a portion of FIG. 2 on a larger scale.

DESCRIPTION OF EXEMPLARY EMBODIMENT OF INVENTION

Referring initially to FIG. 1 of the drawings, designated generally therein by the numeral 10 is a vibratory earth compacting roller which has a smooth surface in the particular construction illustrated. However, it may also be of the sheep's foot type if desired.

Referring to FIG. 2 for the moment, the roller 10 is provided at its ends with headers 12 which carry axially-outwardly projecting stub shafts 14 rotatable relative to suitable roller supports 16 in bearings 18. As is well known in this art, the roller supports 16 are connected to an earth compacting vehicle, not shown, through suitable vibration isolating structures, not shown.

Disposed within and coaxial with the roller 10 is a rigid, tubular eccentric housing 20 which is rigidly connected at its ends to the roller headers 12 and the stub shafts 14 in any suitable manner. As will become apparent, the ends 22 of the eccentric housing 20 contain bearings 24 for an eccentric shaft 26 of the invention. Thus, the eccentric housing 20 permanently fixes the axial spacing and alignment of the eccentric bearings 24 so that there is no change in the relationship between these bearings with growth of the roller or drum 10, which is an important feature of the invention. Drum growth in use is accommodated by distortion of the headers 12.

The eccentric shaft 26 is a composite structure which includes a relatively stiff, rigid tube or tubular housing 28 having end closures 30 secured thereto, as by welding. The end closures 30 comprise stub shafts which extend into the bearings 24 to mount the tube 28 and its end closures 30 for rotation about the axis of the tube. The eccentric shaft 26 is driven by a coaxial drive shaft 32 having a splined connection to one of the end closures 30. The drive shaft 32 is suitably rotatably mounted within the corresponding roller stub shafts 14, and is equipped at its outer end with a drive sheave 34.

The composite eccentric shaft 26 also includes an eccentric bar 36 within and extending longitudinally of and spaced radially inwardly from the eccentric shaft tube or housing 28. The eccentric bar 36 is provided with ends 38 coaxial with the tube 28 and respectively carried by the end closures 30. The eccentric bar 36 is suitably connected to the end closures 30, as by pins 40, so that the eccentric bar rotates with the tube 28 and the end closures 30 about the axis of the tube.

With the foregoing construction, the eccentric bar 36, which is relatively flexible, can flex to a considerable extent during rotation of the eccentric shaft. However, the rigid eccentric shaft housing 28 virtually eliminates any deflection of the composite eccentric shaft 26 at the eccentric bearings 24, thereby maximizing bearing life, which is an important feature. Also, the eccentric bar 36 has a relatively low moment of inertia, with the result that the composite eccentric shaft 26 requires a very low starting effort and requires minimum power in operation, which are additional important features.

Turning now to another aspect of the invention, coaxial with the eccentric shaft housing 28, and suitably fixed on the stub shafts formed by the end closures 30 thereof, are impellers 42 located adjacent and axially outwardly of the eccentric bearings 24. As will

be discussed in more detail hereinafter, the impellers 42, in response to rotation of the eccentric shaft 26, draw fluid through the eccentric bearings 24 into toroidal chambers 44 in the inner ends of the roller stub shafts 14. The chambers 44 communicate with the annulus 46 between the eccentric housing 20 and the eccentric shaft 26 through the eccentric bearings 24. They also communicate with the interior of the eccentric shaft housing 28 through inlet ports 48 in the end closures 30. The latter also carry plugs 49 provided with relatively small, metering outlet ports 50, FIG. 5, which communicate with the eccentric bearings 24 and which are located radially inwardly of the eccentric shaft tube or housing 28. The plugs 49 are interconnected by a longitudinal tube 51 having central lubricant inlets 53, FIG. 2, and containing a filtering material 55, FIG. 5, such as stainless steel wool, at each end.

The eccentric shaft housing 28 is provided intermediate its ends with radially-inwardly extending vents 52 interconnecting the interior of the housing 28 and the annulus 46. These vents are also provided with ports 54 intermediate their outer and inner ends, as best shown in FIG. 3.

Disposed within the eccentric system defined by the eccentric housing 20 and the eccentric shaft 26 therein is a quantity of liquid lubricant, such as oil. During rotation of the eccentric shaft 26, the oil within the eccentric shaft is displaced radially outwardly by centrifugal force, and, as shown in FIG. 3, occupies the space radially outwardly of the dotted line 56. This annular body of oil is under pressure because of the centrifugal force acting thereon, with the result that oil flows from the eccentric shaft housing 28 through the tube 51 and the metering ports 50 and into the eccentric bearings 24, thereby lubricating the bearings continuously as long as the eccentric shaft is rotating, which is an important feature. Since the tube 51 is spaced radially inwardly from the eccentric shaft housing 28, solid contaminants in the oil are held against the housing 28 by centrifugal force and cannot flow through the tube 51 into the eccentric bearings 24. Any contaminants that do enter the tube 51 through its inlet ports 53 are filtered out by the filters 55. Consequently, frequent changing of the oil and flushing of the eccentric system are unnecessary. The relatively long tube 51 requires all the oil to flow to the center of the eccentric shaft 26 before reaching the bearings 24, thereby producing better cooling. Still another feature is that the centrifugally induced oil pressure insures proper bearing lubrication, even if the roller 10 is on a slope with one bearing 24 above the other.

The oil flowing from the metering ports 50 through the eccentric bearings 24 is returned to the interior of the eccentric shaft 26 through the inlet ports 48 by the impellers 42, the circulation of oil throughout the eccentric system being indicated by solid arrows in FIGS. 2 and 3 of the drawings. Some of the oil in the centrifugally formed oil annulus within the eccentric shaft 26 flows through the ports 54 and the vents 52 into the annulus 46 between the eccentric housing 20 and the eccentric shaft housing 28. This oil is cooled by contact with the eccentric housing 20, which is an important feature, and is returned to the interior of the eccentric shaft 26 by the impellers 42, by way of the eccentric bearings 24 and the inlet ports 48. Thus, the ports 54 in

the vents 52 provide a further metered flow of cooled oil to the eccentric bearings 24.

In addition to the oil, the impellers 42 circulate cooling air throughout the eccentric system, as indicated generally by the broken arrows. More particularly, the cooling air circulated by the impellers 42 flows into the eccentric shaft 26 through the inlet ports 48, and then escapes into the annulus 46 through the vents 52. While in the annulus 46, the air is cooled by contact with the eccentric housing 20, and returns to the impeller chambers 44 by way of the eccentric bearings 24.

Thus, the eccentric system of the invention is provided with a closed lubricating and cooling system, the oil and the air within the system being continuously circulated through the eccentric bearings 24, so that the oil lubricates same, and being continuously circulated through the annulus 46 for cooling purposes. Solid contaminants are trapped against the inner surface of the eccentric shaft housing 28 so that they cannot enter the tube 51 leading to the eccentric bearings 24. Further, since this is a closed system, solid contaminants build up at a very slow rate so that frequent changing of the oil and flushing of the system are unnecessary. These, and the various other advantages and results hereinbefore set forth in detail, are all important features of the invention.

If desired, the roller 10, may be filled with water ballast to increase its weight. Such water ballast also enhances the cooling of the lubricant and air within the eccentric housing 20 by carrying heat by convection to the roller 10 and its headers 12. If complete or substantially complete filling of the roller 10 is not desired from the weight standpoint, a similar water cooling effect can be achieved with a small amount of water with the structure of FIG. 4. Therein the roller 10 is shown as equipped with buckets or scoops 60, which may be angles secured to the roller periphery, and adjacent ones of which face in opposite directions. With this construction, the roller 10 may contain a small amount of water 62, which the buckets 60 pick up and drop onto the housing 20, as indicated at 64, for either direction of roller rotation. Thus, enhanced cooling is achieved with even a small amount of water by carrying heat to the roller 10.

Although exemplary embodiments of the invention have been disclosed herein for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiments without departing from the scope of the invention as defined by the claims appearing hereinafter.

I claim as my invention:

1. In an eccentric system for a vibratory apparatus, the combination of:

- a. a tube;
- b. bearings respectively supporting the ends of said tube for rotation about the axis thereof;
- c. an eccentric in and spaced radially from said tube and having ends coaxial with and respectively carried by said ends of said tube, with said eccentric fixed to said tube; and
- d. means for rotating said tube and said eccentric about the axis of said tube.

2. An eccentric system as set forth in claim 1 wherein said eccentric is a bar extending longitudinally of said

tube with its center of mass spaced radially from the axis of said tube.

3. An eccentric system according to claim 2 wherein said tube is provided with end closures respectively carried by said bearings.

4. An eccentric system as set forth in claim 3 including a tubular outer housing enclosing said tube and carrying said bearings in fixed axially spaced relation.

5. An eccentric system as defined in claim 3 including an outer housing enclosing said tube and said bearings, and including means for circulating a lubricant between said tube and said housing through said bearings.

6. An eccentric system as set forth in claim 5 wherein said lubricant circulating means includes impellers respectively adjacent said bearings and rotatable with said tube about the axis thereof.

7. An eccentric system according to claim 6 wherein

said end closures are provided with inlet ports communicating with said impellers and through which said impellers pump the lubricant into said tube, and are further provided with metering outlet ports communicating with said bearings for metering the lubricant from said tube to said bearings.

8. An eccentric system per claim 7 including a longitudinal lubricant line interconnecting said metering ports and having inlet ports intermediate its ends.

9. An eccentric system as defined in claim 8 including air discharge ports in said tube for the discharge of air pumped into said tube through said inlet ports by said impellers.

10. An eccentric system as defined in claim 4 including means for contacting the exterior of said outer housing with a coolant.

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