May 11, 1965 G. L. MALAN 3,182,964

VIBRATOR

Filed Feb. 19, 1963 2 Sheets-Sheet 1

FIG. 1

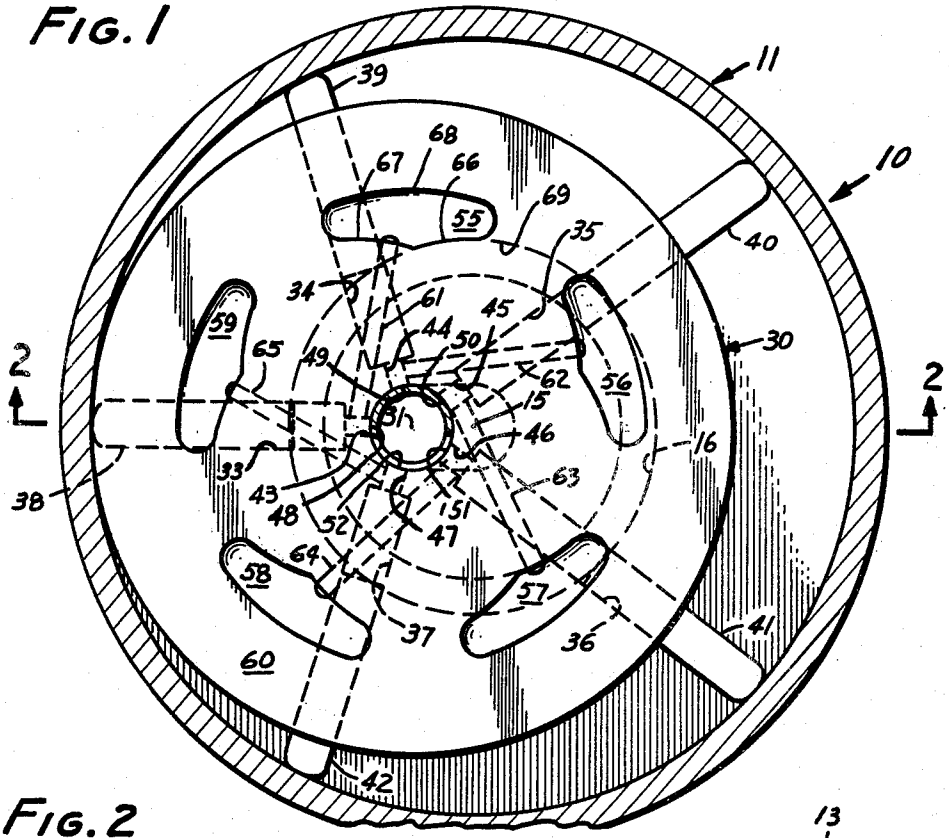


FIG. 2

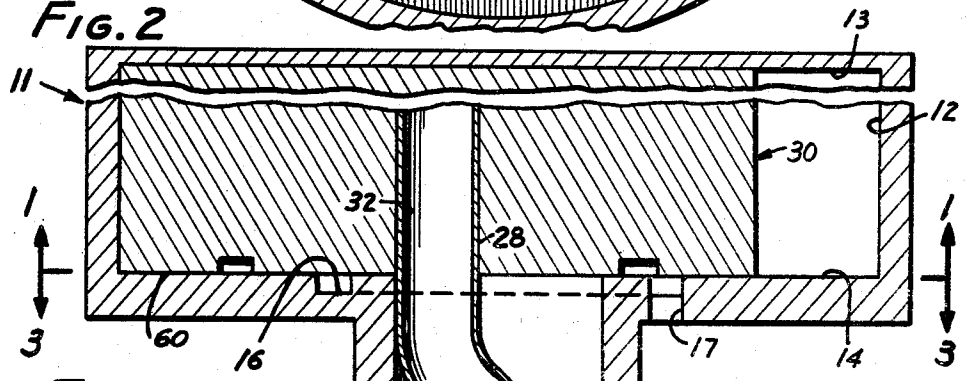
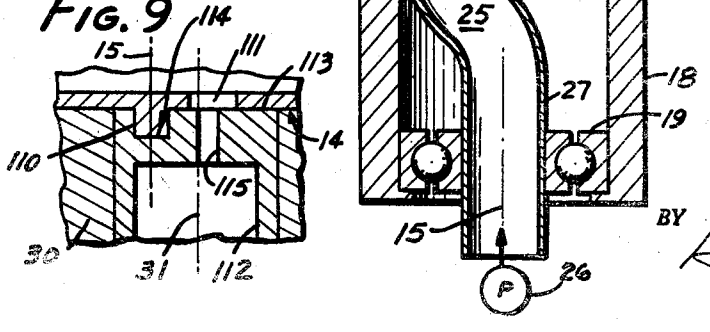


FIG. 9



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FIG. 3

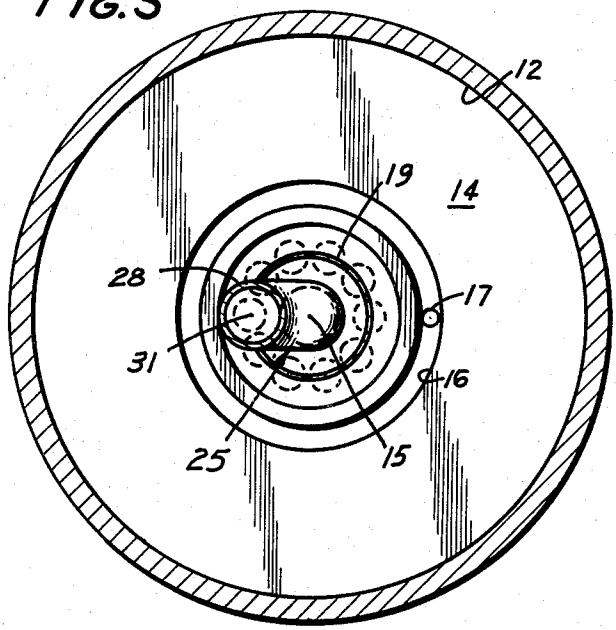


FIG. 5

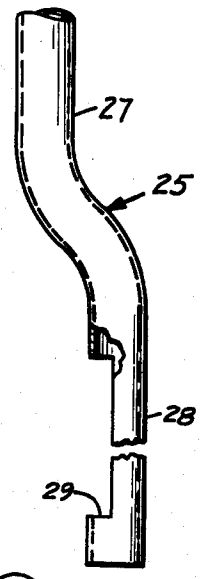


FIG. 4

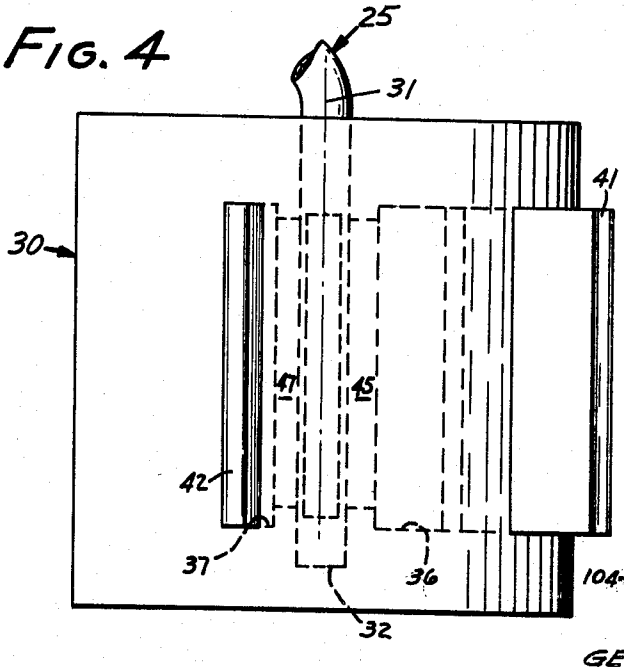


FIG. 6

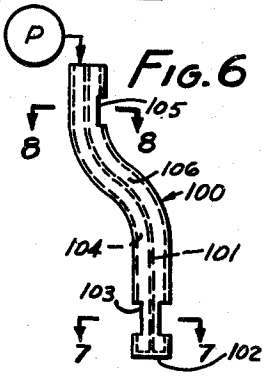


FIG. 7



FIG. 8



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3,182,964

VIBRATOR

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Filed Feb. 19, 1963, Ser. No. 259,503
10 Claims. (Cl. 259—1)

This invention relates to vibrators, and particularly to that type of vibrator in which a rotor runs freely around the inside of a race in a stator, thereby generating lateral vibratory forces. This type of vibrator finds its principal usefulness in settling and distributing concrete in forms.

Free-rotor vibrators are well known in the art. They have the considerable advantages of being expedient to manufacture and to repair, of being rugged and having a longer life than most other types of vibrators, and of producing a very substantial quantum of energy at high vibratory frequencies using the power of pressurized fluids. Devices of this general class are illustrated by George L. Malan Patents Nos. 2,187,088; 2,743,090; and 2,891,775. Such devices are presently in wide and successful using throughout the world.

The geometry and construction of these vibrators make it more practical to run them with gases such as compressed air, than with pressurized liquids. When operated on liquids, their output frequencies and efficiencies have tended to fall below those attainable with compressed gases. A problem inherent in the use of compressed gases is that in order to get sufficient energy out of the gas to move the rotor at a sufficient rate, it has been found necessary to apply pressure to the rather large region between the race and the rotor. This is accomplished by forming compartments between vanes which extend the full length of the rotor and the race. This has required considerable valving at the ends of the rotor. However, the loci of the operative portions of the rotor are such that they dictate a severely limited geometrical arrangement of valving elements which does not permit optimum vibrator operation on any motive fluid, and which renders nearly impossible operation on liquids.

In construction operations, there has recently arisen a need for vibrators which can operate effectively on pressurized liquids, and which can produce frequencies and energy outputs, while using such liquids, which are comparable to those attainable with compressed gases. Another recent need is for such vibrators which require a lesser total rotor throw. These advantages are not generally attainable with known devices. Supplying these needs will have the significant additional advantage that those new devices which can be operated successfully on compressed liquids will also operate successfully on gases. Then the vibrator is more versatile.

It is an object of this invention to provide a free-rotor vibrator in which only the exhaust is controlled by contact between the rotor and the housing which contains it, thereby freeing the vibrator design from an entire set of design parameter limitations which arise from concurrently valving the pressure supply at the same surfaces.

An optional object of this invention is to provide valving means for a vibrator in which valving means no valving action occurs between adjacent faces of the rotor and the housing.

Still another object of this invention is to provide a vibrator wherein intake valving is accomplished as a function of the angular orientation of the rotor in the race.

Still another object of the invention is to provide a rotor in which forces can be exerted between the stator and the rotor without requiring pressurizing of the region between them.

A vibrator according to this invention includes a stator having an internal race with a pair of end supports. The

race and end supports define an internal cavity in the housing. A rotor of lesser lateral and equal axial dimensions with the cavity is disposed inside the cavity. Both the rotor and the cavity have longitudinal axes, which axes are parallel.

An exterior peripheral bearing surface is formed on the rotor which is adapted to bear against the internal race in free rolling contact therewith. The rotor has an axial distributor passage opening on one end thereof, and a plurality of substantially radially-extending plunger passages opening onto the bearing surface. Respective plunger supply passages interconnect the plunger passages to the distributor passage. Each plunger supply passage opens onto the distributor passage at a respective plunger supply opening. The plunger supply openings are angularly spaced apart around the distributor passage.

A distributor shaped as an offset tubular element is journaled to the housing and to the rotor. The distributor has a pressure port through its wall which extends around less than its full periphery and is thereby adapted sequentially to overlap the supply openings.

A plunger is placed in each of said plunger passages, and each is adapted to be extended by fluid force behind it, and to be retracted into the rotor by end loading exerted by the race.

In one embodiment of the invention, a plurality of exhaust ports is formed in at least one end face of the rotor. Each plunger passage is in fluid communication with a respective supply opening and with a respective exhaust port. The exhaust ports are symmetrically disposed around the rotor axis. In this embodiment, an exhaust groove in one of the end supports is adapted sequentially to overlap the exhaust ports. The exhaust port and supply opening associated with a respective plunger are not in concurrent registration with the exhaust groove or the pressure port. Such registration is alternative and sequential.

In another embodiment, the distributor is compartmented, to provide an exhaust passage with an exhaust port through its wall, which, with the pressure port, makes alternative contact with the supply openings. In this embodiment, the exhaust ports in the rotor can be dispensed with.

The above and other features of this invention will be fully understood from the following detailed description and the accompanying drawings in which:

FIG. 1 is a cross-section taken at line 1—1 of FIG. 2;

FIG. 2 is a cross-section taken at line 2—2 of FIG. 1;

FIG. 3 is a cross-section taken at line 3—3 of FIG. 2;

FIG. 4 is a side elevation of the rotor in FIG. 1;

FIG. 5 is an elevation of the distributor in FIG. 1;

FIG. 6 is an elevation of an alternate form of distributor;

FIGS. 7 and 8 are cross-sections taken at lines 7—7 and 8—8, respectively, of FIG. 6; and

FIG. 9 shows still another embodiment of the invention.

FIG. 1 illustrates the presently preferred embodiment of an eccentric rotary vibrator 10 according to the invention. This device includes a housing 11 which has an internal cylindrical race 12 and a pair of end supports (sometimes called "end restraints") 13, 14 (FIG. 2). The internal race has a longitudinal axis 15. The inner faces of end supports 13 and 14 are normal to axis 15. A circular exhaust groove 16 is sunk in the surface of end support 14. End support 14 is pierced by an exhaust passage 17 which leads to atmosphere or to a reservoir as appropriate to the type of fluid being used for power. Exhaust groove 16 is concentric with axis 15.

The housing carries a bearing support 18. A bearing 19 is held in this support, and is concentric with axis 15.

A tubular offset distributor 25 is journaled to the in-

ternal race of bearing 19. The tubular passage of the distributor is connected to a source of fluid under pressure such as pump or compressor 26. The distributor is an offset pipe having first and second legs 27, 28, which legs are parallel. Leg 27 rotates around axis 15.

As can be seen in FIG. 5, a pressure port 29 is formed in the wall of the distributor. This pressure port extends around approximately 170° of the periphery of the distributor and for only part of its length. The lower end of the distributor in FIG. 5 may be closed, if desired, which would avoid an end-loading force between the distributor and the rotor in which it fits. Alternatively, it may merely make a close fit as shown. A reasonably close fit is desirable so that there will not be excessive leakage past the edges of the pressure port.

Rotor 30 is disposed within the cavity formed by the internal race and the end supports. It has a longitudinal axis 31 parallel to axis 15. The axial length of the rotor is about equal to the axial separation of the end supports, so that the two ends of the rotor are in sliding contact with the end supports.

The lateral dimensions of the rotor are less than the corresponding axial dimensions of the race so that it can freely roll around inside the race. As can be seen in FIG. 2, when the rotor is in contact with the internal race, axes 15 and 31 are spaced apart by the same distance as the center lines of the legs of the distributor so that rolling rotation of the rotor within the race will cause crank-arm rotation of the distributor. It will be observed that rotation of the rotor in this manner does not require lateral support by the distributor. The race supports the rotor as it rolls around.

The rotor has an internal axial distributor passage 32. It opens on at least one end of the rotor. In the illustrated embodiment, it opens adjacent to end support 14 and admits leg 28 of the distributor in the rotary fit described above.

Five radially extending plunger passages 33, 34, 35, 36, 37 are formed in the sidewall of the rotor. Each extends less than the full axial length of the rotor, so that they do not open onto the ends of the rotor. Plungers 38, 39, 40, 41, 42 are fitted in the plunger passages so as to be reciprocable therein. Their outer tips are generally rounded to avoid binding against and scouring the race. The plungers are of lesser length than the plunger passages which they fit as can be seen from an examination of FIG. 1. They can be made either longer or shorter, as desired. The importance of the arrangement shown is that, in contrast to most previously known free rotor vibrators, the plunger passages do not interrupt the end faces of the rotor. This leaves greater areas available for valving, and markedly reduces the design limitations.

It is unnecessary for the outer periphery of the rotor to contact the race over its full axial length. The lateral support by the race, and the forces exerted by the plungers, can be exerted over different areas, and, if desired, the inner wall of the housing could be recessed so that rolling contact would occur in some regions, and plunger contacts in others, without rolling contact in the latter. Then the rotor would roll on surfaces which could not possibly be galled or otherwise spoiled by plunger contact.

Each plunger passage has a respective plunger supply passage 43, 44, 45, 46, 47, connected to it, which latter open onto the distributor passage at respective plunger supply openings 48, 49, 50, 51, 52. These openings are angularly spaced around the wall of the distributor passage where they will be sequentially overlapped by pressure port 29.

Five exhaust ports 55, 56, 57, 58, 59 are formed in end 60 of the rotor, which end is in sliding contact with end support 14. Plunger exhaust passages 61, 62, 63, 64, 65 interconnect ports 55–59 with plunger supply passages 43–47, all respectively.

Exhaust port 55 will be described in detail, it being understood that it is typical of exhaust ports 55–59, inclusive. Assuming that axis 31 is to move clockwise around axis 15, with the rotor in rolling contact with the race, then there will occur a counter-clockwise rotation of the rotor around its own axis 31. With this arrangement, edge 66 of exhaust port 55 is a trailing edge, edge 67 is a leading edge, and edge 68 is an outer limiting edge. All of these edges have the same curvature as outer edge 69 of exhaust groove 16.

Plunger supply openings 48–52, exhaust ports 55–59, and plunger passages 33–37 are all spaced equally around the axis 31 so as to undergo their operations sequentially.

FIGS. 6–8 illustrate an alternate type of distributor 100 which can be substituted for distributor 25 in the embodiment of FIG. 1. Distributor 100 can be used with the same rotor and housing as in FIG. 1. More importantly, if desired, the exhaust ports at the end of the rotor, and the exhaust ring in the end support can be dispensed with, and all valving can thereafter be accomplished by the distributor. Then the rotor and housing design is rendered completely free from any geometrical limitations imposed by need for periodical registration of elements at the end of the rotor. Among other advantages, wider variations of ratios between rotor and race diameters can then be attained.

Distributor 100 has a longitudinal partition 101 running for its full length. It may conveniently be capped at one end by cap 102. A pressure port 103 is formed through the sidewall of the distributor into pressure passage 104. An exhaust port 105 is formed through the sidewall of the distributor into exhaust passage 106.

The exhaust and pressure ports each have an angular extent of about 170°, although they may be made even greater by stepping their elevations on the distributor. They are both disposed at such an elevation as sequentially to register with every plunger supply opening 48–52.

Distributor 100 is identical to distributor 25 except for the partition and ports, and can be directly substituted for it. Pressure passage 104 is connected to a source of pressure. Exhaust passage 106 discharges to a reservoir or atmosphere, depending on the fluid being used for motive power. Conventional connections may be used, which need not be disclosed here.

FIG. 9 shows a modified end plate 14 with a central nib 110 on axis 15. Air passages 111 pass fluid from the pressure port. A distributor 112 is fitted in rotor 30, which rotor is identical to that in FIG. 4. The distributor includes an end member 113 having a sink 114 to receive the pin, this sink being off rotor axis 31, so that cranking movement is derived from rotation of axis 31 around the pin, the distributor being on an offset element in the same sense as those of FIGS. 5 and 6. Ports 115 pass pressure from passages 111 to the distributor.

The operation of the embodiment of FIGS. 1–5 will now be described. Exhaust groove 16 is overlaid in FIG. 1 to illustrate the relative movements of the contiguous surfaces of the rotor and the end support.

The device is actuated by introducing pressure into the central passage of the distributor where it becomes available for distribution at pressure port 29. As can best be seen in FIG. 1, wherein the unsectioned portion represents the opening 29, plunger supply openings 51 and 52 are in position to receive pressurized fluid and supply them to the inside edges of plungers 41 and 42, thereby tending to move these plungers radially outward, and the rotor upward in FIG. 1, assuming the rotor remains stationary. Because the rotor is in rolling contact with the race, this motion makes the rotor rotate counter-clockwise around its own axis, and the distributor rotates clockwise around axis 15. Such operation brings supply opening 48 next into communication with port 29.

It will be observed that, as illustrated, exhaust port 55 is just leaving an overlapping (registered) condition with exhaust groove 16, its trailing edge just being congruent with the outer edge of the groove. Exhaust ports 58 and

59, which are respectively associated with plungers 41 and 42, are entirely out of contact with the exhaust groove, and are closed by the end support.

Exhaust ports 56 and 57, which are respectively interconnected with plungers 39 and 40, are in overlapped (registered) condition with exhaust groove 16, thereby exhausting the plunger passages at the rear edges of the plungers, and permitting these plungers to be pressed back into their respective recesses as the rotor rolls around. This expels the fluid through the respective exhaust passages and exhaust ports into groove 16 when their exhaust ports register with groove 16.

The sequential operation of this device can be deduced from the foregoing, because the opening 29 will rotate around axis 31 so as sequentially to pressurize plunger supply openings 48, 49, 50, 51, 52 in that order. The exhaust ports at the end of the rotor will overlap exhaust grooves 16 only when pressure port 29 is not in fluid communication with the respective plunger supply opening, thereby providing for alternate and sequential supply and exhaust of fluid to the plunger passages. The dimensions of the device are so arranged that as soon as the pressure is cut off, one of the exhaust ports begins to communicate with the exhaust groove and so that as soon as the exhaust ports move out of registration with the exhaust groove, then there is pressure on in the respective pressure supply port. This sharply defined alternative action enables incompressible liquids to be used for power without causing rough operation.

The operation of the embodiment of FIGS. 6–8 is identical to that of FIGS. 1–5. Sequential pressurizing of the supply ports is accomplished by the pressure port of the distributors in the identical manner. Sequential exhaust connections are made by the exhaust port's registering with the supply ports at the same angular positions as the rotor occupies when the end porting is used. The end porting may be dispensed with, such as by closing or eliminating groove 16, or the ports in the end of the rotor, or may be used concurrently with the exhaust porting in the distributor.

In any event, this embodiment provides the same alternation of pressure and exhaust connections as that of FIGS. 1–5.

It will be recognized that while five plungers presently appear to be the optimum number, still more or fewer of the same may be utilized as desired, simply by increasing or decreasing the number and spacing apart of the respective sets of elements.

The fluid is confined entirely to the regions in the ports and passages and the portion of the recesses behind the plungers so that there is no need to seal the region between the rotor, the race, and the plungers. This enables the end face of the rotor to be utilized only for exhaust control instead of for both exhaust and pressure control, and thereby reduces the complexity and internal passages inside the rotor. Furthermore, it cuts down the length of the internal passages by utilizing a relatively large cross-sectional area distributor all the way to a location closely adjacent to the plunger passage. All of these features enable pressurized liquids to be utilized with great advantage and enables an inelastic liquid to be utilized instead of an elastic fluid, because the volumetric relationships and the cut-on and cut-off positions can be closely adjusted. However, elastic fluids such as compressed air can also be used to power the vibrator embodiments shown herein.

The embodiment of FIGS. 1–5 is shown with exhaust and pressure connections at only one and the same rotor end. These could, of course, be provided at different, or at both, ends.

The embodiment of FIGS. 6–8 has the additional advantage that surface contact between end supports and the rotor can be minimized, because sealing at that area can be dispensed with. The end supports need merely restrict the axial position of the rotor to regions where the supply openings will register with the distributor openings. Frictional loads at the ends of the rotor can thereby be minimized. For example, end supports in the form of peripheral rings could be used instead of full-area contact end plates, and both end restraints need not be in simultaneous contact with the rotor, because considerable end play is allowable when the distributor ports and the supply ports are sufficiently axially elongated to provide axial overlap over a range of axial positions of the rotor in the housing.

The operation of the embodiment of FIG. 9 is similar to that of FIGS. 1 and 2. In this embodiment, nib 110 remains on the central axis 114, and as the rotor rotates around in the race, passage 115 describes a circle around axis 114 remaining in contact with passages 111 so that air under pressure is always available to the inside of distributor 112. The geometrical relationships within the rotor as to porting arrangements between the distributor and the rotor are the same as in FIGS. 1 and 2.

This invention is not to be limited by the embodiments shown in the drawings and described in the description which are given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

I claim:

1. An eccentric rotary vibrator comprising: a housing; an internal cylindrical race in said housing; a pair of end supports in said housing, said race and end supports defining an internal cavity therein, said cavity having an axis; a rotor inside said cavity having an axis, lesser lateral dimensions than the race, and substantially equal length as the cavity, an exterior peripheral surface, at least a portion thereof being a peripheral cylindrical bearing surface adapted to bear against the race in rolling contact therewith, said rotor having an axial distributor passage opening at one end thereof, a plurality of substantially radially extending plunger passages opening onto said peripheral surface, a plunger supply passage interconnecting each of said plunger passages to the distributor passage, a supply opening for each of said plunger passages, said supply openings being angularly spaced apart around said distributor passage, and a plurality of exhaust ports in at least one end face of the rotor, each plunger passage being in fluid communication with a respective supply opening and a respective exhaust port, said exhaust ports being symmetrically disposed around the rotor axis; a distributor comprising an offset element journaled to the housing and in the distributor passage, said distributor having pressure port means therein adapted sequentially to overlap the supply openings; an exhaust groove in one of said end supports adapted sequentially to overlap the exhaust ports; and a plunger in each of said plunger passages adapted to be extended to contact the housing, and to be retracted, thereby to roll the rotor in the race by virtue of alternate connections of plunger passages to the pressure port means of the distributor through the respective supply openings, and to the exhaust groove through the respective exhaust ports.

2. A vibrator according to claim 1 in which the length of the plungers measured along the axis of the rotor is less than the length of the axis of the rotor.

3. A vibrator according to claim 1 in which the exhaust ports each includes a leading and a trailing edge, each of which has an arc of curvature substantially equal to that of an edge of the exhaust groove.

4. A vibrator according to claim 1 in which the distributor is an offset tube having a pair of parallel legs, and in which bearing means is provided on the housing coaxial with the axis of the housing journaling one leg of said distributor, the other leg of the distributor being journaled in the rotor.

5. A vibrator according to claim 1 in which the end supports are planar and in which the ends of the rotor are planar.

6. A vibrator according to claim 1 in which there is

provided in addition to said race a surface contactible by the plungers.

7. An eccentric rotary vibrator comprising: a housing; an internal cylindrical race in said housing; a pair of end restraints in said housing, said race and restraints at least in part defining an internal cavity therein, said cavity having an axis; a rotor inside said cavity having an axis, and lesser lateral dimensions than the race, an exterior peripheral surface, at least a portion thereof being a peripheral cylindrical bearing surface adapted to bear against the race in rolling contact therewith, said rotor having an axial distributor passage opening at one end thereof, a plurality of substantially radially extending plunger passages opening onto said peripheral surface, a plunger supply passage interconnecting each of said plunger passages to the distributor passage, a supply opening for each of said plunger passages, said supply openings being angularly spaced apart around said distributor passage, each plunger passage being in fluid communication with a respective supply opening, said supply openings being symmetrically disposed around the rotor axis; a distributor comprising an offset element journaled to the housing and in the distributor passage, said distributor having pressure port means and exhaust port means therein adapted alternatively and sequentially to overlap the supply openings; a pressure passage and an exhaust passage in the distributor, communicating respectively with the pressure and exhaust port means in the distributor; and a plunger in each of said plunger passages adapted to be extended to contact the housing, and to be retracted thereby to roll the rotor in the race by virtue of alternate connections of plunger passages to the pressure and exhaust port means of the distributor through the respective supply openings.

8. A vibrator according to claim 7 in which the length of the plungers measured along the axis of the rotor is less than the length of the axis of the rotor.

9. A vibrator according to claim 7 in which the distributor is on offset tube having a pair of parallel legs, and in which bearing means is provided on the housing coaxial with the axis of the housing journaling one leg of said distributor, the other leg of the distributor being journaled in the rotor.

10. A vibrator according to claim 7 in which there is provided in addition to said race a surface contactible by the plungers.

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CHARLES A. WILLMUTH, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,182,964 May 11, 1965

George L. Malan

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, line 9, for "on" read -- an --.

Signed and sealed this 28th day of September 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents