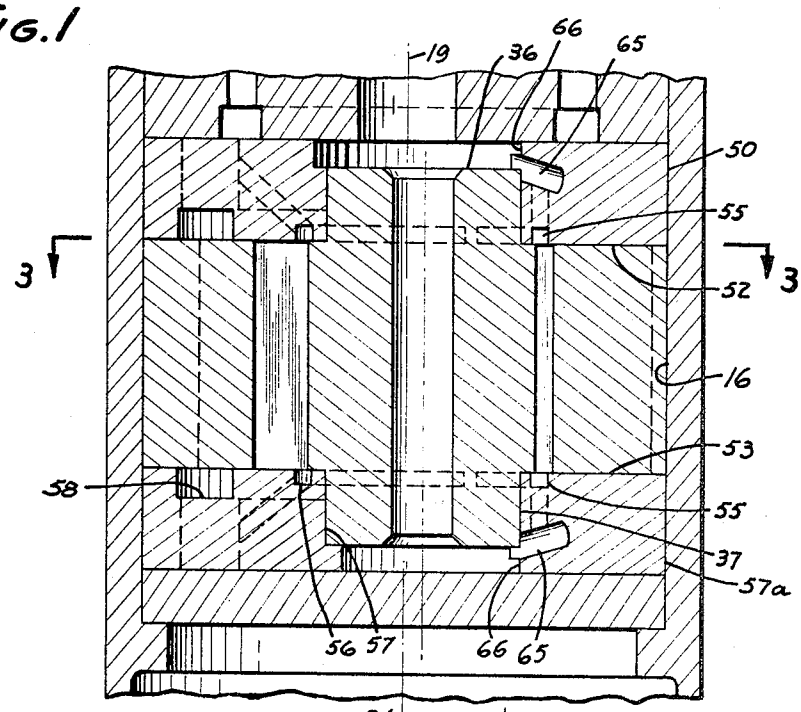
Nov. 1, 1966 G. L. MALAN 3,282,570

VIBRATOR

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FIG. 1



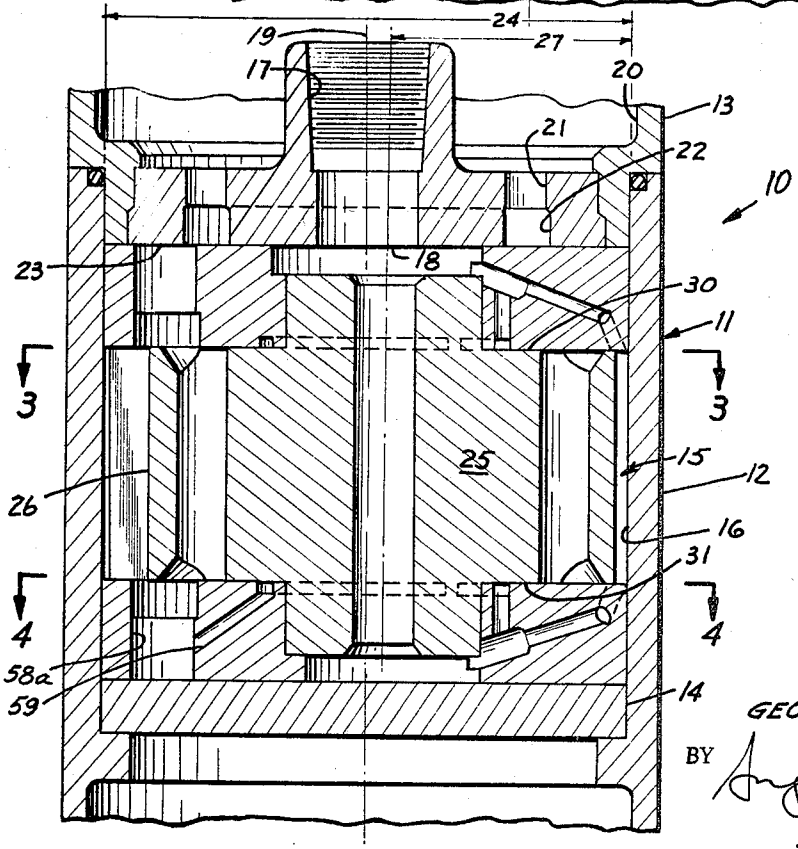


FIG. 2

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FIG. 5

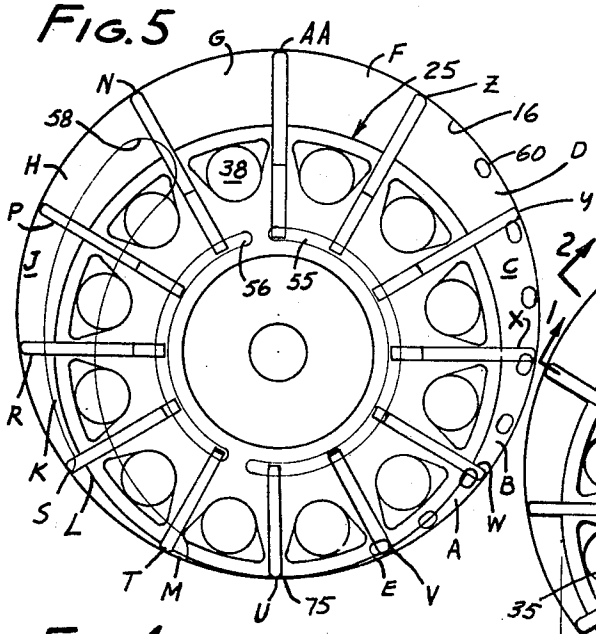


FIG. 3

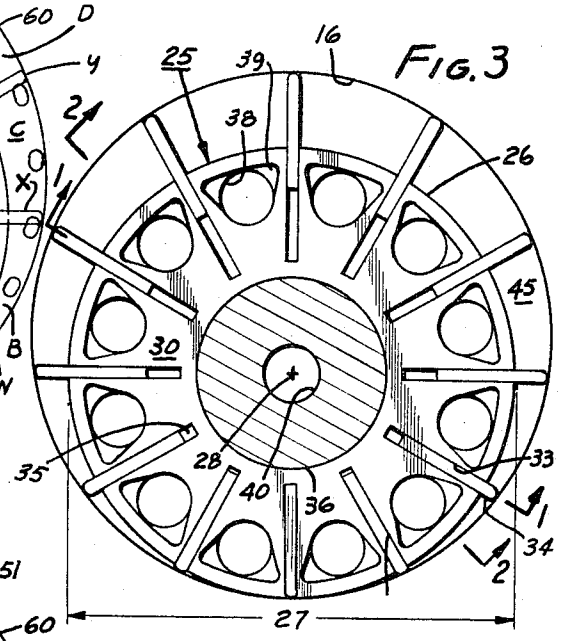


FIG. 4

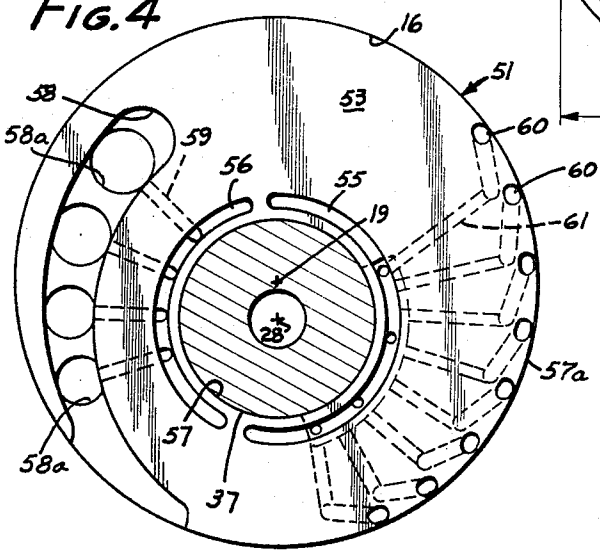
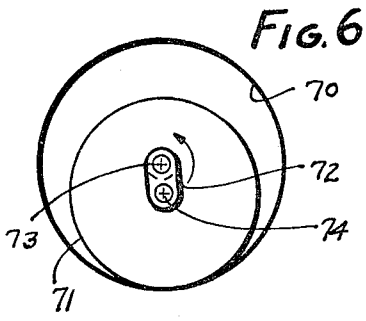


FIG. 6



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3,282,570

VIBRATOR

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Filed June 23, 1965, Ser. No. 466,204
17 Claims. (Cl. 259—1)

This application is a continuation-in-part of applicant's co-pending patent application Serial No. 287,408, filed June 12, 1963, entitled, "Vibrator," now Patent No. 3,193,256, issued July 7, 1965, which in turn is a continuation-in-part of patent application Serial No. 185,479, filed April 5, 1962, entitled, "Vibrator With Separate Bearing and Compartment-Forming Surfaces," now Patent No. 3,129,925, issued April 21, 1964. This application relates to a free-rotor vibrator with improved structure and characteristics.

The term "free-rotor vibrator" is utilized to described a class of vibrator wherein an internal rotor orbits around inside a cylindrical race whereby to exert unbalanced centrifugal forces directly against the race. This construction distinguishes it from another class of vibrator wherein an eccentric weight is whirled around a shaft so as to exert unbalanced centrifugal forces on the shaft, and through the shaft on the case. The problems of these vibrators are distinct, and this application relates only to free-rotor types.

There is increasing interest in stepping up the frequency of free-rotor vibrators and increasing their output, while still keeping the weight of the vibrator to a sensible minimum. In order to do this, the vibrator must be able to tolerate a throughput of fluid, either gas or liquid, of a relatively higher volume than has heretofore been possible, and also preferably should take advangtage of the expansive energy of a gas when this class of fluid is used.

It is an object of this invention to provide a simple free-rotor vibrator of rugged construction and simple geometry, which vibrator inherently cannot stall in a central inoperative position and which can, when using gas as a power source, utilize the expansive power of the gas, and further can operate at higher frequencies than has heretofore been possible with conventional vibrators.

A vibrator according to this invention comprises a case that has an internal cavity with a central axis and supply and exhaust ports which lead into the cavity. A cylindrical compartment-forming surface partially bounds the cavity and this surface has a first diameter centered on the said central axis. A free-rotor is placed in said cavity, and it is adapted to roll around inside the case in bearing contact therewith in order to exert unbalanced centrifugal forces on the case. The rotor has a central axis. An external cylindrical compartment-forming surface is formed on this rotor which may or may not bear against the compartment-forming surface on the case. The compartment-forming surface on the rotor has a second diameter which is smaller than the opposite diameter of the case. The compartment-forming surface on the rotor is centered on the central axis of the rotor. This rotor has a plurality of vane recesses that open into the rotor from its compartment-forming surface. The axes of the rotor and cavity are parallel to each other.

A vane is slidably disposed in each of the vane recesses and each of them is adapted to extend beyond the compartment-forming surface of the rotor in order to make contact with the compartment-forming surface of the cavity and to be retracted into the respective recess by force exerted on it by the compartment-forming surface of the cavity. Respective compartments are formed between adjacent vanes in the compartment-forming surfaces. A vane chamber is formed inside each recess

which is bounded by the vane and the walls of the recess.

An eccentric element comprises a body having a pair of offset parallel bearings, the first being rotatably mounted to the case on its central axis and the second being rotatably mounted to the rotor on its central axis, whereby the eccentric element rotates around the case axis when the rotor orbits in the case.

Compartment ports and passages and vane chamber ports and passages are so disposed and arranged sequentially and periodically to supply fluid under pressure to the vane chambers and to the compartments, and to exhaust the same, whereby to cause the rotor to orbit in the cavity.

According to a preferred but optional feature of the invention, the eccentric element is laterally restrained by the case, and itself laterally restrains the rotor whereby to exclude the rotor from assuming a position wherein the axes are coincident.

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

FIGS. 1 and 2 are cross-sections taken at lines 1—1 and 2—2 of FIG. 3, respectively;

FIGS. 3 and 4 are cross-sections taken at lines 3—3 and 4—4, respectively, of FIGS. 1 and 2;

FIG. 5 is a partial overlay of FIGS. 3 and 4 to show the respective operations; and

FIG. 6 is a top cutaway view, showing an alternate embodiment of a portion of the invention.

The presently preferred embodiment of the invention is best shown in FIG. 2. Vibrator **10** includes a case **11** that has a tubular element **12** and end members **13**, **14**. A cavity **15** is formed inside the case and is at least partially bounded by a cylindrical compartment-forming surface **16**. A pressure port **17** passes into the case and opens at a supply port **18** on the central axis **19** of the case and cavity. A coaxial exhaust line **20** surrounds the pressure port and is connected thereto by a plurality of exhaust holes which are in communication with a continuous exhaust groove **22**, which also is coaxial on axis **19**. It will thereby be seen that at face **23** of the cavity there is a continuous connection available to pressure at port **18** and to exhaust at groove **22**. The case has a first diameter **24**. Fluid under pressure, such as compressed air, is applied at port **17**, and line **20** goes to atmosphere or reservoir.

A free rotor **25** (FIG. 3) is fitted inside the cavity, and extends from end to end thereof. It has an external compartment-forming surface **26** which is cylindrical and which has a second diameter **27** that is smaller than first diameter **24**. Diameters **24** and **27** are centered around their respective axes **19** and **28** respectively. With reference to FIG. 3, it is intended that the rotor orbit clockwise inside compartment-forming surface **16** while at the same time rotating counterclockwise around its own axis **28**. In so doing, the compartment-forming surfaces will bear against each other to act as bearing surfaces for transmitting centrifugal forces from the rotor to the case, although the compartment-forming and bearing functions could, if desired, be separated as in applicant's United States Patent Number 3,219,925.

The rotor has a pair of boundary surfaces **30**, **31** which boundary surfaces are surfaces of revolution which might assume different shapes, but preferably are planar as shown in FIG. 2. FIG. 3 illustrates surface **30**, it being understood that boundary surface **31** is a mirror image of the same, the elements described herein extending therethrough and being duplicated at both ends.

A plurality of vane recesses **33** is formed in the compartment-forming surface **26** of the rotor, and extends radially thereinto. These vane recesses also open onto

the boundary surfaces. Within each of these recesses there is provided a vane 34 which is extensible beyond the compartment-forming surface, and is retractable thereinto by forces exerted against the end thereof by compartment-forming surface 16. Within the recess and at the inner end of each there is a vane chamber 35 of variable volume, the volume depending upon the extension of the vane. The inner ends of the vane recesses stand on a circle centered on the central axis 28 of the rotor.

The rotor includes a pair of bearings 36, 37 which are centered on axis 28. Exhaust passages 38 pass axially through the rotor from boundary surface to boundary surface and have flared portions 39 at each of their ends. There is one of these passages 38 between each pair of vanes.

A central, axially extending pressure passage 40 extends between the ends of bearings 36 and 37.

Compartments 45 are formed between adjacent pairs of vanes and the compartment-forming surfaces 16 and 26. It will be understood that occasionally a compartment will be divided in two by the tangency of the two compartment-forming surfaces but that all but one, and sometimes all, of the regions between adjacent pairs of vanes will at any time be bounded by two vanes and the compartment surfaces on the rotor and on the case. An examination of FIG. 3 will indicate that if the compartments on the right hand side of the figure were placed under pressure, and those on the left hand side were placed under exhaust, and the vanes on the pressure side were kept pressed against the compartment-forming surface of the case, then the rotor would tend to orbit clockwise inside surface 16. It is the purpose of this invention to cause that motion to occur by supplying pressure and exhaust connections to the appropriate compartments and vanes at the appropriate times.

For the above purpose there are supplied a pair of eccentric elements 50, 51 these elements each including a boundary surface 52, 53, respectively, which bears against respective bounding surfaces 30 and 31 of the rotor. It is to be understood that only one contiguous pair of these bounding surfaces is necessary to the operation of the vibrator, but that improved performance may be expected by balancing up the vibrator by supplying a set at each end. In order to simplify the drawings, boundary surface 30 has been shown in FIG. 3 and boundary surface 53 has been shown in FIG. 4. These are not contiguous surfaces. Instead the contiguous surfaces would be 30 and 52. However, surface 52 is the mirror image of surface 53 and an adequate showing of the interaction between the two surfaces would not be possible. Therefore for the purpose of simplifying the illustrations, an overlay has been provided in FIG. 5 which shows the reaction between overlaid surfaces 30 and 52 utilizing for illustration, however, surface 53 which is the mirror image of the surface 52 which would be in actual contact with boundary surface 30.

Only surfaces 30 and 53 will be described in detail, it being understood that the mirror image of either would be required to be in surface to surface sealing contact with the other. FIG. 4 shows eccentric element 51, which again is the mirror image of eccentric element 50 whereby to simplify the understanding of the drawings of the invention. In boundary surface 53 there is an arcuate pressure groove 55 centered on axis 28 of the rotor. There is an exhaust groove 56 which is similarly centered and they are separate and apart from one another. A bearing surface 57 is formed in the eccentric element on axis 28 to receive bearing 37. The external surface of the eccentric element is of the same diameter as diameter 24 and rotates therein. It is centered on axis 19 of the case so that the eccentric element is journaled in the case and axis 28 rotates clockwise around axis 19.

A compartment exhaust port 58 is formed in boundary surface 53, and certain of the exhaust passages 58*a* can be seen passing therethrough. Additional exhaust passages

59 connect to exhaust groove 56. A plurality of compartment supply ports 60 are spaced apart from one another along an arc in boundary face 53 and connect through compartment supply passage 61 to pressure supply groove 55.

Now with reference to FIG. 1, it will be seen that pressure supply groove 55 is supplied with pressure through a passage 65 that in turn communicates with a central port 66 in the end of the eccentric element. There is therefore always a source of pressure at groove 55. Similarly, exhaust groove 56 is connected by exhaust passage 58*a* to port 58 and thence through passages 38 to groove 22. Thus groove 56 is always under exhaust conditions.

It will be noted that because the eccentric elements are restrained to the case by a bearing and restrained to the rotor by a bearing, these bearings being parallel to and offset from each other, that the rotor, while it may freely contact the case can never move laterally inward, such that the axes would coincide under which circumstances the device might be rendered inoperable. Instead it serves to exclude them from this position and to keep the elements of the device in proper geometric relationship.

A similar scheme is shown in FIG. 6 wherein a compartment-forming surface 70 has within it a rotor 71 and in which an eccentric element 72 on the order of a crank arm is journaled to the case by one bearing 73 and to the rotor by another bearing 74 thereby providing the same exclusion from a coincident axis condition.

The operation of the invention will be fully understood with reference to FIG. 5, in which the overlay indicates the relationship between the eccentric elements, the rotor, and the compartment-forming surface 16 of the case. It will be observed that compartments A, B, C, and D are under pressure as supplied by ports 60 which overlay them. Compartment E is about to receive fluid under pressure by the said overlap. This overlap is caused because the rotor is orbiting clockwise and the compartment-forming surface of the rotor is receding from surface 16 in these compartments. Point 75 represents the point of tangency between the rotor and the end surface 16. Compartment F is increasing in volume, and compartment G is about to decrease in volume. However, the increase in the volume of compartments F and G from the size presently occupied by compartment D was accomplished under power of expansion of the gas which they contained, because there is no exhaust connection to them at this time. Compartments H, J, K, L, and M are decreasing in volume, because the rotor is rolling toward them in this position. Exhaust port 58 is overhanging these latter compartments and serving to exhaust them and is about to begin to overlap compartment G.

As to the vanes, as the volume of the compartments formed is to decrease the vanes must retract into the rotor by force exerted from the case, and there should be exhaust pressure behind them. For this purpose exhaust groove 56 has overlapped vanes N, P, R, S and T. On the other hand when the compartments are under power the vanes should be extended and for this reason supply groove 55 is overlapping chambers behind vanes U, V, W, X, Y, Z and AA. As the rotor turns relative to the eccentric element, then the different vane chambers will register with the same. For example, with further rotation port 56 will overlap the chamber behind vane AA and groove 55 will move off that chamber while the vane chamber behind vane T will move away from port 56 and overlap port 55.

The above-described sequential operation causes the condition of FIG. 5 to move smoothly around the axis as the pressure conditions go on in sequential compartments and behind sequential vanes and the exhaust conditions go on in sequential compartments and behind sequential vanes, there preferably but not necessarily being one or two compartments in which there exists yet the opportunity for expansion under the power of gas which has already been supplied thereto. This action causes the

rotor to orbit in the case, and this orbiting causes the unbalanced centrifugal force which is used for purposes such as settling and distributing concrete in forms, or for compacting earth.

Because this device is subject to such closed timing, it has been found possible to use it both with compressed air or with other gases and with hydraulic fluids. Speeds as high as 7,000 r.p.m. have readily been attained, and its simplicity radically reduced repair and maintenance.

FIG. 6 illustrates a simplification of the device wherein a simple crank is utilized to exclude the rotor from a centralized position. It will be understood that the crank of FIG. 6 may be utilized with or independently of the eccentric element shown in the other figures and that either one pair or two pair of these eccentric elements with mating bounding surfaces on the rotor may be used as desired.

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. A vibrator comprising: a case having an internal cavity with a central axis and supply and exhaust ports; a cylindrical compartment-forming surface partially bounding said cavity having a first diameter centered on said central axis; a free rotor in said cavity adapted to roll around inside the case in bearing contact therewith in order to exert unbalanced centrifugal forces on said case, the rotor having a central axis; an external cylindrical compartment-forming surface on said rotor having a second diameter which is smaller than said first diameter and centered on the central axis of the rotor, said rotor having a plurality of vane recesses opening into the rotor from its compartment-forming surface, and also opening into the rotor from a boundary surface which is a surface of revolution that lies obliquely to the axis, the axes of the rotor and the cavity being parallel; a vane slidably disposed in each of said vane recesses and adapted to extend beyond the compartment-forming surface of the rotor to make contact with the compartment-forming surface of the cavity and to be retracted into the respective recess by force exerted on it by the compartment-forming surface of the cavity, respective compartments being formed between adjacent vanes and the compartment-forming surfaces; a vane chamber being formed inside each recess which is bounded by the vane and the walls of the recess, and which opens on the boundary surface; and an eccentric element comprising a body having a pair of offset but parallel bearings, the first being rotatably mounted to the case on its central axis, and the second being rotatably mounted to the rotor on its central axis, whereby the eccentric element rotates around the case axis when the rotor orbits in the case; and ports and passages so disposed and arranged in the eccentric element as sequentially and periodically to supply fluid under pressure to the vane chambers and to the compartments, and to exhaust the same, whereby to cause the rotor to orbit in the cavity.

2. A vibrator according to claim 1 in which the eccentric element is laterally restrained by the case, and itself laterally restrains the rotor, in such a manner as to exclude the rotor from assuming a position wherein the axes are coincident.

3. A vibrator according to claim 1 in which the eccentric element includes a boundary surface contiguous to a boundary surface on the rotor, said ports in the eccentric element opening on to said boundary surface of the rotor, and in which the case supply and exhaust ports are in continuous communication with respective passages in the eccentric element.

4. A vibrator according to claim 3 in which the said boundary surfaces are planar.

5. A vibrator according to claim 3 in which ports in the eccentric element comprise a supply port and an exhaust port, adapted to overlay sequential vane chambers so as to apply elevated or exhaust pressure conditions thereto.

6. A vibrator according to claim 5 in which said supply and exhaust ports in the eccentric element comprise arcuate ports centered on the central axis of the eccentric element, a plurality of adjacent vane chambers simultaneously overlapping each of the same.

7. A vibrator according to claim 3 in which the ports in the eccentric element comprise supply and exhaust openings in the said boundary surface of the eccentric element which extends over a respective arcuate region sufficient that each overlaps a plurality of compartments.

8. A vibrator according to claim 7 in which the ports in the eccentric element comprise a supply port and an exhaust port, adapted to overlay sequential vane chambers so as to apply elevated or exhaust pressure conditions thereto.

9. A vibrator according to claim 8 in which said supply and exhaust ports in the eccentric element comprise arcuate ports centered on the central axis of the eccentric elements, a plurality of adjacent vane chambers simultaneously overlapping each of the same.

10. A vibrator according to claim 9 in which the supply and exhaust openings in the eccentric element are fluidly interconnected with respective ones of said arcuate ports.

11. A virbator according to claim 3 in which said boundary surfaces, and ports in the eccentric element, are duplicated at both ends of said rotor, and in which passage means extends through the rotor to provide supply and exhaust conditions at both ends.

12. A vibrator according to claim 3 in which said vanes are uniformly spaced around the axis of said rotor.

13. A vibrator according to claim 3 in which the eccentric element comprises a circular disc rotatably fitted in the cavity, and includes an offset hole to receive a circular shaft centered on the axis of the rotor.

14. A vibrator comprising: a case having an internal cavity with a central axis and a cylindrical surface partially bounding said cavity and extending axially therein; a free rotor having an external cylindrical surface of smaller diameter than said first-named cylindrical surface and a central axis, whereby the rotor may roll around in said cavity to exert unbalanced centrifugal forces on the cylindrical surface bounding the cavity, and an eccentric element with a first and second bearing, each bearing being restrained to rotation about a respective one of said axes, said eccentric element leaving unimpeded the bearing contact of rotor and case, but excluding the rotor from a position wherein the axes are coincident.

15. A vibrator according to claim 14 in which the eccentric element is a crank.

16. A vibrator according to claim 14 in which the eccentric element comprises a circular disc rotatably fitted in the cavity, and includes an offset hole to receive a circular shaft centered on the axis of the rotor.

17. A vibrator comprising: a case having a cavity; an internal cylindrical compartment-forming surface in said cavity, having a first diameter, a rotor within the cavity continuously adapted to bear against the case having a central axis and an external compartment-forming surface having a second diameter, the said surfaces each having an axis, said axes being parallel and normally displaced from one another; a plurality of vanes carried in vane chambers in the rotor, which vanes are reciprocable within, extensible beyond, and axially coextensive with, the compartment-forming surface on the rotor, and thereby being adapted to form a compartment between a pair of adjacent vanes and the two compartment-forming surfaces; and fluid supply and exhaust means for causing rolling movement of the rotor within the case by periodically placing compartments under greater and lesser pressures, the rotor being in constant rolling contact with the

case during said rolling movement, the fluid supply and exhaust means including an eccentric element journaled to the case and to the rotor about the respective axes and being thereby adapted to turn as a crank when the rotor rolls in the case, the eccentric element having supply and exhaust passages which are adapted to be connected to a supply of pressurized fluid and to a collector of exhaust fluid, respectively, and also having supply and exhaust ports to communicate with the vane chambers and with

the compartments for sequentially applying pressure and exhaust connections thereto.

References Cited by the Examiner

UNITED STATES PATENTS

3,171,634 3/1965 Malan ---------- 259—1

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J. M. BELL, *Assistant Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,282,570 November 1, 1966

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 1, line 11, for "July 7," read -- July 6, --; column 2, line 62, for "3,219,925" read -- 3,129,925 --; column 5, line 75, for "in which ports" read -- in which the ports --; column 6, line 29, for "virbator" read -- vibrator --.

Signed and sealed this 5th day of September 1967.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents