

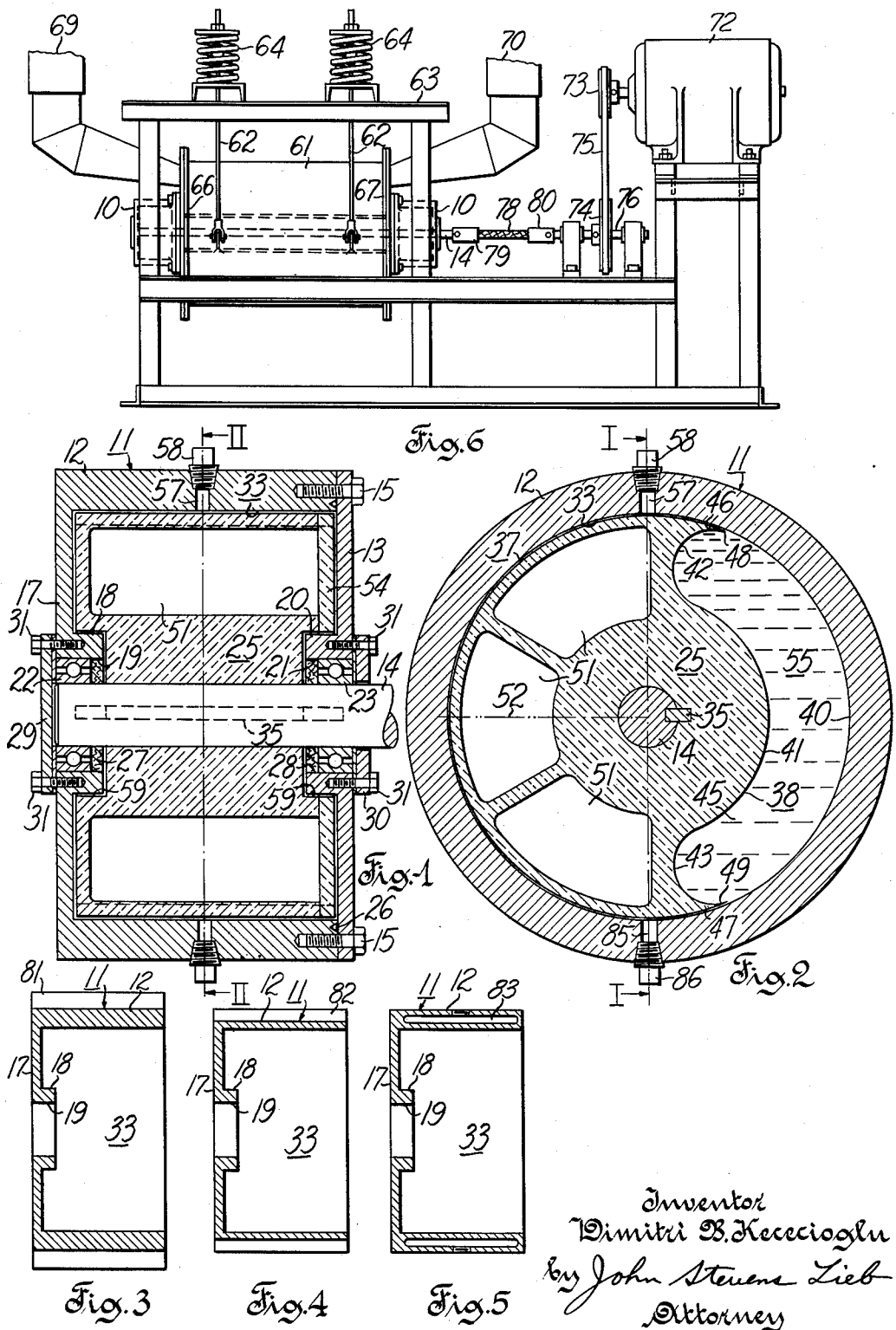
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FLUID WEIGHT VIBRATOR

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FLUID WEIGHT VIBRATOR

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The present invention relates generally to a device for producing vibratory motion and more particularly to a device of the type in which an unbalanced centrifugal force created by rotating an eccentrically disposed mass is utilized to impart circular vibratory movement to the device.

This type of device or vibrator can be attached to a vibratable body (such as a vibrating ball mill, a vibrating screen, or the like) either internally or externally thereof.

Prior art devices of this type which have heretofore been constructed include a vibrator comprising a housing having internal walls defining a cylindrical chamber in which eccentrically disposed weight means are rigidly connected to a rotatable shaft mounted coaxially within the chamber.

A disadvantage of this type vibrator is that the unbalanced centrifugal force which is created is transmitted to the vibratable body through the shaft and the bearings in which the shaft is journaled thereby necessitating excessive replacement of these bearings because of the intense strain under which they operate.

A second prior art vibrator of this type has disposed within the chamber eccentrically positioned weights not attached to the shaft. These weights may be either balls or rollers. Attached to the shaft is an impeller which, upon rotation of the shaft, engages the balls or rollers so as to cause the balls or rollers to move. The unbalanced centrifugal force thus created by the movement of the eccentrically positioned weights is transmitted to the vibratable body through the vibrator housing.

A disadvantage of this type vibrator occurs from the combined circular and random radial and axial movement of the balls or rollers within the chamber. This movement creates an appreciable amount of friction which results in considerable heat generation and a very low efficiency in the conversion of input energy to transmittable vibratory movement.

Another disadvantage of this type vibrator also arises from the combined circular and random radial and axial movement of the balls or rollers within the chamber since this movement results in a series of random collisions among the balls or rollers and in a series of random collisions between the balls or rollers and the inner surface of the chamber or housing. The impact of these collisions is sufficient to erode substantial portions of the balls or rollers and to pit the inner wall to the end that these members are ultimately substantially consumed and ineffectual in achieving their designated function.

Another disadvantage of this type vibrator is that the random movement of the weight means renders it impossible to efficiently lubricate the vibrator since there is no one surface upon which all contact takes place.

A further disadvantage of this type vibrator is the noisiness of operation caused by the balls or rollers striking each other and the housing.

A third prior art vibrator of this type substitutes a liquid, such as mercury or liquid babbit, for the balls and

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rollers providing the weight means in the above mentioned second prior art device and uses a solid cylindrical impeller having a cutout portion therein arcuately defined between radii of the impeller to impel the liquid weight means disposed in and partially filling the cavity.

A disadvantage of a vibrator of this type is that in operation the centrifugal force created by the rotation of the impeller and the movement of the liquid causes a smearing effect which results in "painting" the inner surface of the chamber with the liquid, that is, the centrifugal action creates an annulus of liquid between the impeller and the housing which annulus impedes the movement of the impeller and reduces the effective energy available for vibratory movement for a given energy input.

Another disadvantage of this type vibrator is that the random movement of the liquid partially filling the cavity causes vibrations which cannot be controlled and therefore may be in opposition to the desired movement during part of each revolution.

Accordingly, it is the primary object of the present invention to provide an improved vibrator which overcomes the heretofore mentioned disadvantages of the prior art vibrators.

Another object of the present invention is to provide an improved vibrator in which the friction between the eccentrically disposed weight means and the surface which guides the weight means is reduced.

Another object of the present invention is to provide an improved vibrator in which the eccentrically disposed weight means is substantially nonconsumable.

Another object of the present invention is to provide an improved vibrator in which the eccentrically disposed weight means does not erode the chamber in which it is disposed.

Another object of the present invention is to provide an improved vibrator in which the amplitude of vibration of the device can be easily and accurately varied.

Another object of the present invention is to provide an improved vibrator in which an eccentrically positioned weight means cooperates more quietly with the surface which directs the travel of the weight means.

Another object of the present invention is to provide an improved vibrator which is a separate and independent unit adapted for a variety of mountings, either internal or external, with a vibratable body.

Another object of the present invention is to provide an improved vibrator in which an eccentrically disposed fluid mass is utilized to create a centrifugal force when the device is rotated.

Another object of the present invention is to provide an improved vibrator in which all of the unbalanced centrifugal force is produced by rotating an eccentrically disposed fluid.

Another object of the present invention is to provide an improved vibrator having smaller and less costly bearings.

Another object of the present invention is to provide an improved vibrator having a smaller and less costly shaft.

A further object of the present invention is to provide an improved vibrator in which the energy losses due to heating are substantially reduced.

A further object of the present invention is to provide an improved vibrator in which the fluid mass is prevented from collecting on the inner walls of the vibrator housing.

A further object of the present invention is to provide an improved vibrator in which more operational energy is available for creating transmittable vibratory movement than is available in prior art vibrators.

A further object of the present invention is to provide an improved vibrator in which the friction drag on the impeller is substantially reduced.

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A further object of the present invention is to provide an improved fluid vibrator in which a given mass of fluid presents a reduced area of contact surface to the inner wall of the chamber within which it is contained.

Still further objects will be apparent and the invention will appear more clearly from the following detailed description of the invention and the accompanying drawings showing, by way of example, a preferred embodiment of the inventive idea.

In the drawing:

Fig. 1 is a vertical section taken along line I—I of Fig. 2 showing the fluid weight vibrator embodying the invention;

Fig. 2 is a vertical section taken along line II—II of Fig. 1 showing in more detail the balanced impeller of the vibrator of Fig. 1;

Fig. 3 is a vertical section through a variant of the housing of the vibrator shown in Fig. 1 (the fluid inlet and outlet plugs and housing end plate having been omitted for clarity) showing the application of fin cooling means;

Fig. 4 is a vertical section through a variant of the housing of the vibrator shown in Fig. 1 (the fluid inlet and outlet plugs and housing end plate having been omitted for clarity) showing the application of slot cooling means;

Fig. 5 is a vertical section through a variant of the housing of the vibrator shown in Fig. 1 (the fluid inlet and outlet plugs and housing end plate having been omitted for clarity) showing the application of liquid coolant jacket cooling means; and

Fig. 6 shows a plurality of vibrators embodying the invention externally attached to a vibrating ball mill.

Referring to Fig. 6 of the drawing, the embodiment chosen to exemplify the invention is vibrator 10.

As shown in more detail in Figs. 1 and 2, the vibrating device or vibrator comprises a housing 11 comprising shell 12 and annular end plate 13 for closing the shell. Through housing 11 passes a rotatable shaft 14. End plate 13 is detachably secured to shell 12 by any suitable means such as bolts 15. Shell 12 has an axial end plate portion 17 having an inwardly extending central annular flange 18 defining an opening 19 therein. Annular end plate 13 comprises an inwardly extending central flange 20 similar to flange 18 and defines an opening 21 in axial register with the opening 19 defined by flange 18. Into openings 19, 21 are respectively inserted conventional bearings, such as antifriction bearings 22, 23 in snugly fitting relationship with flanges 18, 20. Shaft 14, having an impeller 25 rigidly secured thereto, is journaled in bearings 22 and 23. Sealing means 26 is provided between shell 12 and end plate 13. Sealing means 27, 28 are provided at each end of the housing 11 and respectively positioned between bearings 22 and 23 and impeller 25 to seal the housing 11 in fluid tight relationship with shaft 14 and to prevent foreign matter from reaching bearings 22 and 23. Bearings caps 29, 30 are respectively provided on the axial ends of shell 12 and end plate 13 and are detachably secured thereto by suitable fastening means such as bolts 31 for maintaining bearings 22 and 23 in operative position within housing 11. Shell 12, end plate 13, sealing means 26, 27, 28 and shaft 14 define a fluid tight chamber 33.

Impeller 25 is disposed within chamber 33 and is secured to rotatable shaft 14 by any suitable means such as key 35. Impeller 25, as illustrated in Fig. 2, is generally semicylindrical and has an outer periphery having a first and second portion, 37 and 38, respectively. The first portion 37 of the outer periphery of impeller 25 (hereinafter referred to as "impeller portion 37") is arcuate and disposed radially equidistant from shaft 14 and adjacent the inner periphery 40 of housing 11. The second portion 38 of the outer periphery of impeller 25 (hereinafter referred to as "impeller portion 38") comprises an arcuate part 41 and two radially extending

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curved parts 42 and 43, curved parts 42 and 43 merging with arcuate part 41. The arcuate part 41 is disposed radially equidistant from shaft 14 and in spaced relation to inner periphery 40 of housing 11.

Curved parts of radially extending space-confining contours 42 and 43 cooperate with arcuate part 41 of impeller portion 38 and a segment of the inner periphery 40 of housing 11 to define an arcuate cavity 45. Cavity 45 extends radially from inner periphery 40 of housing 11 toward shaft 14 to a locus intermediate housing 11 and shaft 14 and extends longitudinally of shaft 14.

Space-confining contours 42 and 43 merge as hereinbefore described, with arcuate part 41 to complete impeller portion 38. Impeller portion 38 in turn merges with impeller portion 37 to form acute angles 46 and 47 respectively adjacent contours 42 and 43.

Acute angles 46 and 47 respectively provide contours 42 and 43 with scooplike edges 48 and 49 disposed within cavity 45 in such a manner that edges 48 and 49 respectively lead and trail cavity 45 when impeller 25 is rotated. (Fig. 2 assumes counterclockwise rotation.) These edges shall hereinafter be referred to as "leading" and "trailing" edges.

It is understood that although cavity 45 of the impeller 25, as illustrated in Fig. 2, has cylindrically curved contours, any contour which provides an acute angle at the junction of impeller portion 37 and impeller portion 38 is within the scope of the present invention.

Impeller 25 is dynamically balanced by means of a plurality of voids 51 contained therein radially opposite cavity 45, intermediate shaft 14 and impeller portion 37.

The radially extending axis of symmetry 52 of voids 51 is diametrically opposite the radially extending center line of cavity 45, that is, radially extending axis of symmetry 52 is 180° disposed about shaft 14 from the radially extending center line of cavity 45. Voids 51 are covered by any suitable means such as solid annular plate 54 (as shown in Fig. 1), having an outer periphery conforming to the outer periphery of impeller 25. Plate 54 is secured to impeller 25 by any suitable means so as to prevent a fluid 55 from entering voids 51. The balancing of impeller 25 prevents vibrational force from being transmitted to shaft 14 and bearings 22 and 23.

An eccentrically positioned fluid weight means such as a predetermined amount of fluid 55 is introduced into fluid tight chamber 33 through fluid inlet 57 from which fluid inlet plug 58 has been removed, impeller 25 having been previously rotated until cavity 45 was positioned adjacent fluid inlet 57. After fluid 55 has been disposed in cavity 45, fluid inlet plug 58 is replaced in fluid inlet 57 to complete the housing closure.

As hereinbefore alluded to, impeller 25 is so shaped that cavity 45 has its greatest arcuate dimension radially spaced from inner periphery 40 of housing 11 so that the contact surface of fluid 55 with inner periphery 40 of housing 11 between leading edge 48 and trailing edge 49 of cavity 45 is reduced from that taught by the prior art vibrators. This reduced contact surface reduces the friction between the fluid 55 and the inner periphery 40 of housing 11 and further enables a limited contact surface to provide a maximum produced eccentricity. Consequently, more operational energy is available for creating transmittable vibratory motion and the amount of energy needlessly wasted in the generation of undesirable heat by the prior art vibrators is greatly reduced by the vibrator of this invention.

Impeller 25 is provided with undercuts 59 at each axial end thereof to receive flanges 18 and 20.

Fig. 6 shows vibrator 10 mounted in combination with a vibrating ball mill. However, it is understood that any suitable vibratable body, such as a vibrating screen, a vibrating feeder, etc., may be associated with vibrator 10 within the scope of this invention. Likewise it is understood that any suitable method of mounting the vibrator

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on the vibratable body is embraced within the scope of this invention.

The mill illustrated has a generally cylindrically shaped container 61 suspended by a plurality of cables 62 from a stationary overhead supporting structure 63. Resilient means such as springs 64 are attached to each of the cables 62 at the upper end thereof to permit the container 61 to be vibrated relative to supporting structure 63.

Container 61 comprises annularly shaped end walls 66 and 67 having ducts 69 and 70 respectively connected thereto for admitting and discharging material. A suitable drive means such as motor 72 is provided to drive the vibrators 10, 10 and is coupled thereto by any suitable means such as sheaves 73 and 74 and belt 75, sheave 74 being mounted on a shaft 76 which in turn is flexibly coupled to the driven shaft 14 of vibrators 10, 10 by means of flexible cable 78 and detachable sleeves 79 and 80. As shown in Fig. 6, the two externally mounted vibrator units are driven by a common shaft. However, any suitable driving arrangement is within the scope of this invention. Sheaves 73 and 74 and belt 75 merely provide a speed reduction or "gear ratio" mechanism whereby the vibrator can be operated at a speed different from that of the motor. If it is desired to operate the vibrator at the speed at which the motor operates then a direct coupling to the vibrator shaft can be made through a flexible coupling such as that previously described. Another arrangement could of course include a variable speed motor as the driving means.

Figs. 3, 4 and 5 show the adaptation to the outer periphery of the device of various cooling means such as externally mounted fins 81, slots 82, and liquid coolant jacket 83. Each means provides additional heat dissipation so that the normal rate of operation of this device can be greatly exceeded when desirable and the fluid can be maintained within its operable range.

Any dense fluid or fluid suspension may be used in the device as long as it neither freezes nor volatilizes at operating temperatures. Fluids which appear satisfactory under certain conditions are mercury, gallium, tetrabromomethane, methylene iodide, iodine monochloride, selenium oxyfluoride and selenium oxybromide. However, for a given cavity best results are obtained when mercury, the density of which is 13.55 grams per cubic centimeter, is the fluid used in the cavity since mercury allows more weight to be concentrated into a small space than any other fluid presently known. That is to say, when a cavity of fixed dimension is used, the fluid with the greater density provides a greater eccentric force, hence a greater throw for the given space. Consequently, mercury is preferred.

In the embodiment illustrated in Fig. 6, when motor 72 is activated, sheave 73 revolves and by means of belt 75 turns sheave 74 which rotates shaft 76, sleeves 79 and 80, flexible cable 78 and shaft 14 which extends through vibrators 10, 10.

The modus operandi of the device is more clearly understood when Figs. 1 and 2 are observed.

First of all, as hereinbefore mentioned, fluid 55 is introduced in chamber 33 and more particularly in cavity 45 by rotating shaft 14 and impeller 25 until cavity 45 is adjacent fluid inlet 57 from which fluid inlet plug 58 has been removed and introducing fluid 55 through fluid inlet 57 into cavity 45. When cavity 45 has the desired amount of fluid therein, plug 58 is replaced in inlet 57. To evacuate fluid 55 from cavity 45, shaft 14 and impeller 25 are rotated until cavity 45 is opposite fluid outlet 85 from which plug 86 has been removed, and fluid 55 is permitted to drain out. When the desired amount of fluid 55 has been evacuated, shaft 14 and impeller 25 are rotated until cavity 45 is no longer in register with fluid outlet 85 and plug 86 is replaced.

The rotation of shaft 14 in bearings 22 and 23 resulting from the hereinbefore described activation of the drive means causes impeller 25 by means of cavity 45

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and more specifically by means of the scooping action of trailing edge 49 of contour 43 to move the eccentrically positioned mass of fluid 55 in a substantially circular path about the axis of shaft 14 within chamber 33, fluid 55 being suitably restrained by inner periphery 40 of housing 11, to produce a centrifugal force which is transmittable through housing 11 to a vibratable body in connection with which the vibrator may be used thereby imparting vibratory motion to that body.

It is understood that although impeller 25 is shown to be semicylindrical in the drawing, it may be of many various shapes within the scope of this invention limited only by the appended claims.

When impeller 25 is rotated, trailing edge 49 of contour 43 in cavity 45 clears or scoops fluid 55 from inner periphery 40 of housing 11 and pitches it forward in the direction of impeller rotation thereby eliminating the "painting" effect by which an annulus of fluid was deposited on the chamber wall in prior art vibrators. The scooping action of trailing edge 49 resulting from angle 47, besides preventing the fluid 55 from collecting on inner periphery 40 of housing 11, reduces the friction drag on impeller 25 thereby conserving energy for productive work which had heretofore in prior art vibrators been wasted in nonproductive work such as overcoming friction or induced inertia.

The vibrator of the present invention offers the further feature of being easily adapted to provide a variety of vibrational amplitudes. Among the methods suitable for this adaptation are the interchange of impellers having cavities of varying dimensions, the variation of the angular velocity at which the impeller is rotated, and the addition or evacuation of more or less fluid to or from the chamber by means of the fluid inlet or outlet. Of the three methods enumerated, the last is probably the least desirable since the device when operated with a cavity only partially filled with fluid creates force components which may oppose the desired centrifugal force components during a part of each impeller revolution. If in a particular installation, these additional force components are of no consequence, then of course the amplitude of vibration may be changed equally satisfactorily by varying the quantity of fluid contained in the cavity as by the methods previously alluded to as preferred. In any event it is obvious that the amplitude of vibration of vibrator of the present invention can be easily and accurately varied.

The improved operation of the device of the present invention is achieved by the cooperation of the various elements with each other.

By utilizing a fluid which meets the specifications herein set forth, a vibrator is provided in which the eccentrically disposed weight means is substantially nonconsumable so that the costly and vexatious replenishment of weight means inherent in the prior art vibrators is eliminated in the device of this invention. The fluid further eliminates the problem of effectual lubrication since by its nature the fluid is self-lubricating.

While only one embodiment and several modifications thereof of this invention are herein described and illustrated, it is understood that other embodiments and further modifications of the invention may be made and used without departing from the spirit and the scope of the invention as herein described and as set forth in the appended claims.

It is claimed and desired to secure by Letters Patent:

1. A device for producing circular vibratory motion comprising: a housing; a shaft supported for rotation in said housing, said housing encircling said shaft and having an inner periphery defining a chamber coaxial with said shaft; a fluid disposed in said chamber; and an impeller disposed in said chamber and attached to said shaft, said impeller cooperating with said housing for impelling said fluid in a circular path upon rotation of said shaft to produce said motion, said impeller having an outer periph-

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ery having a first and second portion, said first portion being adjacent said inner periphery of said housing and said second portion cooperating with said inner periphery of said housing to define a cavity in said impeller for containing said fluid, said impeller having a trailing edge adjacent said cavity forming an acute angle defined by the junction of said first and second portions.

2. A device according to claim 1 in which said fluid is mercury.

3. A device according to claim 1 in which said impeller presents a segmental cylindrical surface to said housing, said surface having an axially extending cavity defined therein for containing said fluid.

4. A device according to claim 1 in which said impeller is dynamically balanced relatively to said axis of said shaft.

5. A device according to claim 4 in which said impeller is dynamically balanced by having a plurality of axially extending voids having a radially extending axis of symmetry disposed 180° about said shaft from the radially extending center line of said fluid-containing cavity.

6. A device according to claim 1 in which said first portion of said impeller has a running fit with the inner periphery of said housing.

7. A device according to claim 1 having cooling means for dissipating the heat generated by operating said device.

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8. A device according to claim 7 in which said cooling means comprises a plurality of heat dissipating fins spaced about the outer periphery of said housing.

9. A device according to claim 7 in which said cooling means comprises a plurality of slots spaced in the outer periphery of said housing.

10. A device according to claim 7 in which said cooling means comprises a liquid coolant, conduit means disposed in said housing for circulating said coolant; means for introducing said coolant into said conduit means in said housing; and means for withdrawing said coolant from said conduit means in said housing.

11. A device according to claim 1 in combination with a resiliently mounted vibratable body for transmitting said motion to said body.

12. A device according to claim 1 in which said second portion of said impeller has curved axially extending space-confining contours presenting a 180° segment of a cylindrical surface having its axis normal to the radius of said impeller which passes therethrough.

13. A device according to claim 1 in which said first portion of said impeller extends circumferentially not less than 180°.

No references cited.