Feb. 15, 1949. G. T. HEMMETER 2,461,643

DYNAMIC BALANCER

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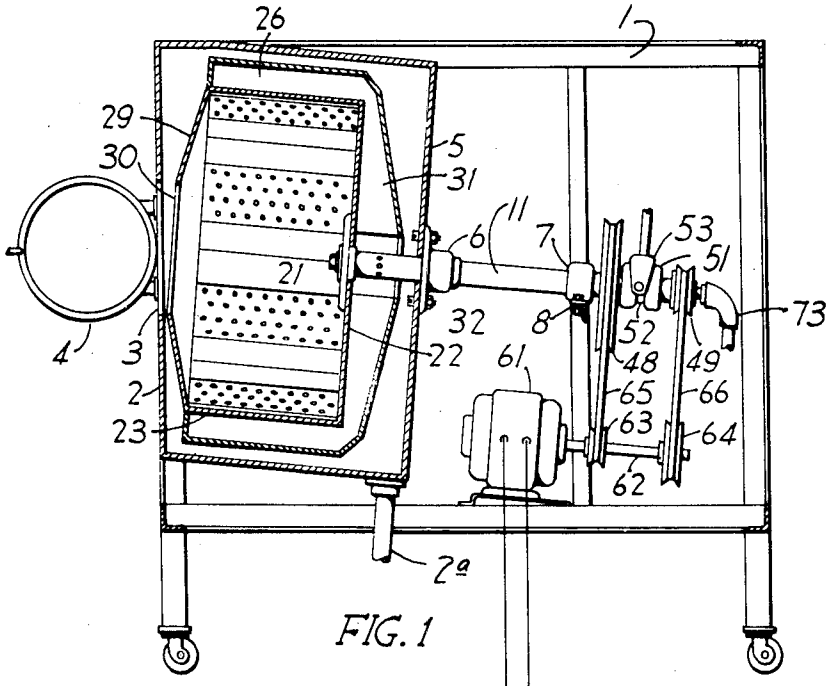


FIG. 1

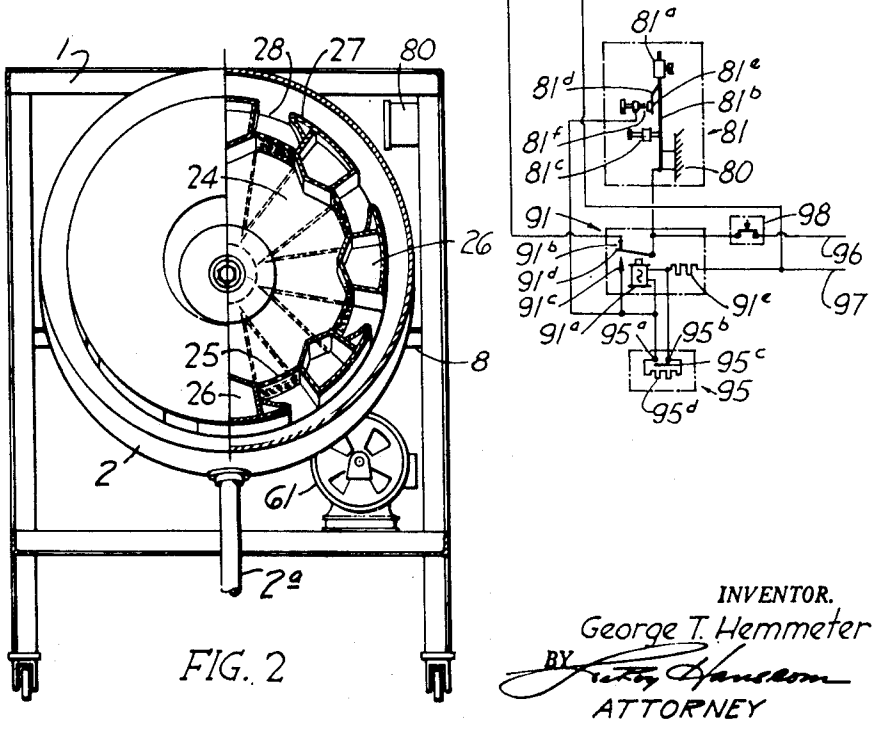


FIG. 2

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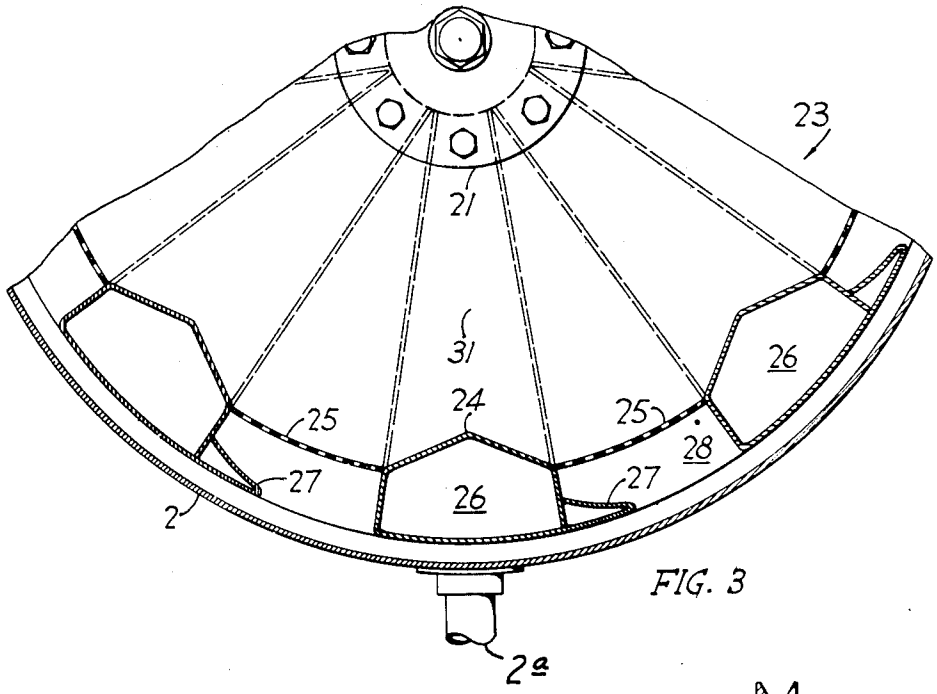
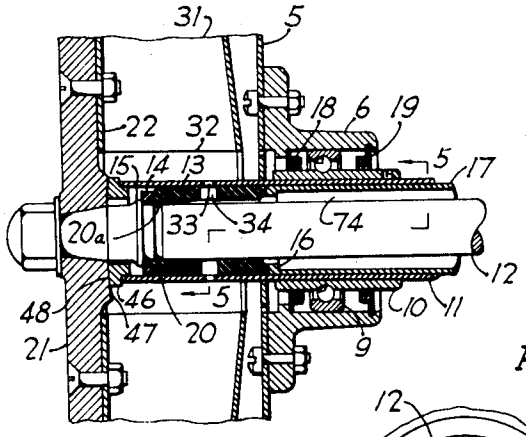


FIG. 3



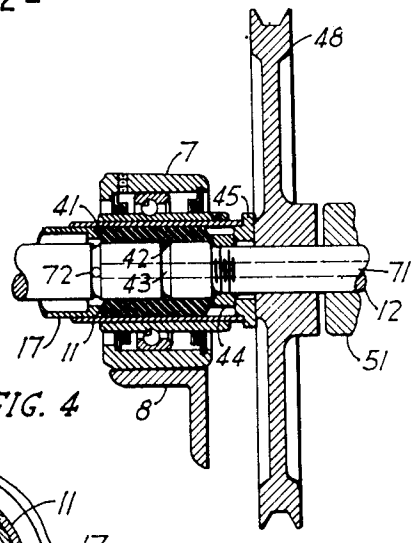


FIG. 4

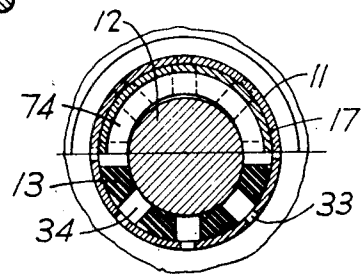


FIG. 5

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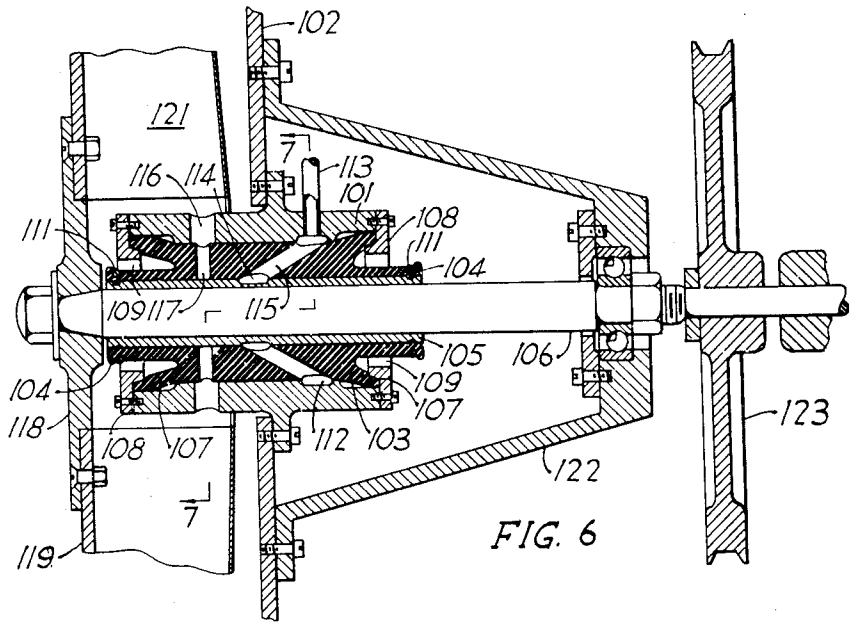


FIG. 6

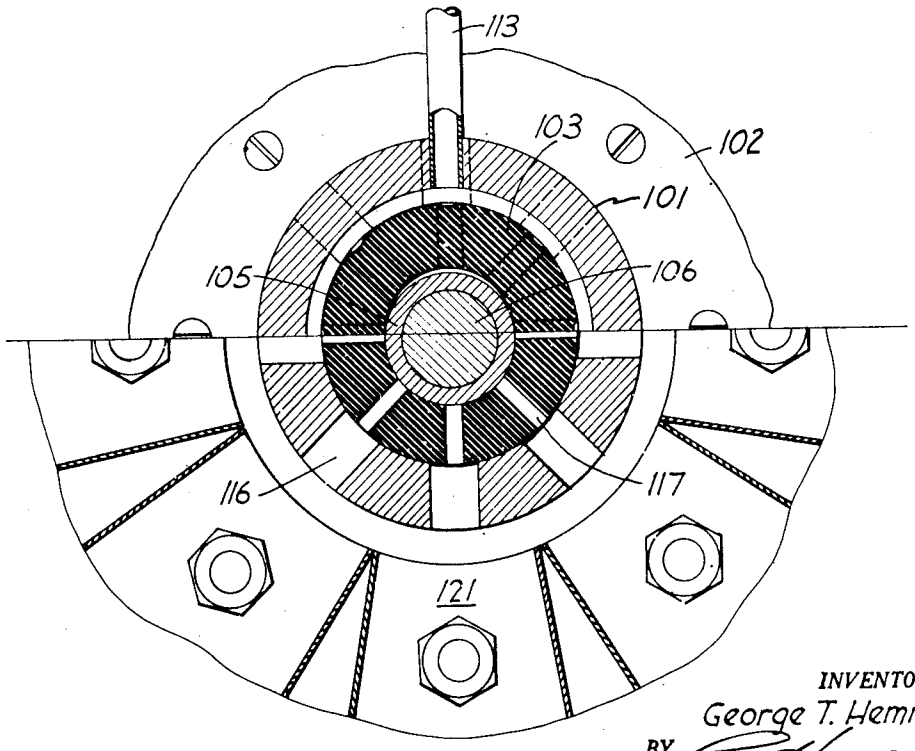


FIG. 7

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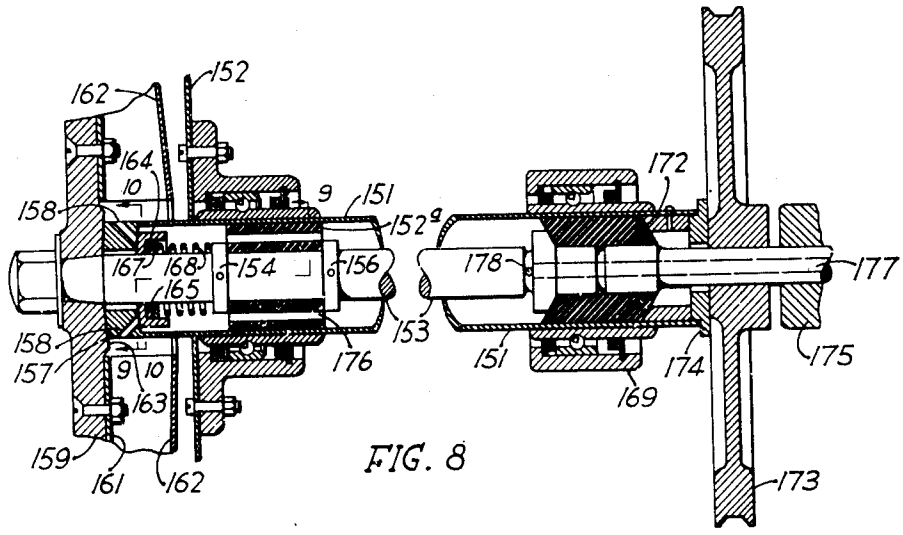


FIG. 8

FIG. 9

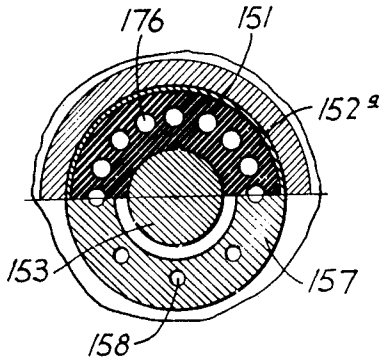
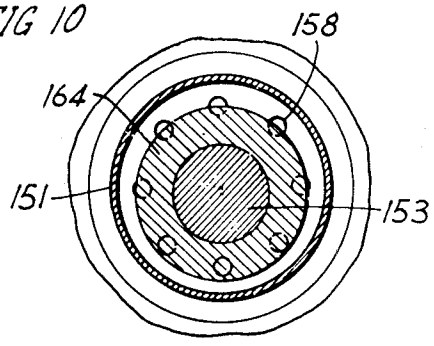


FIG 10



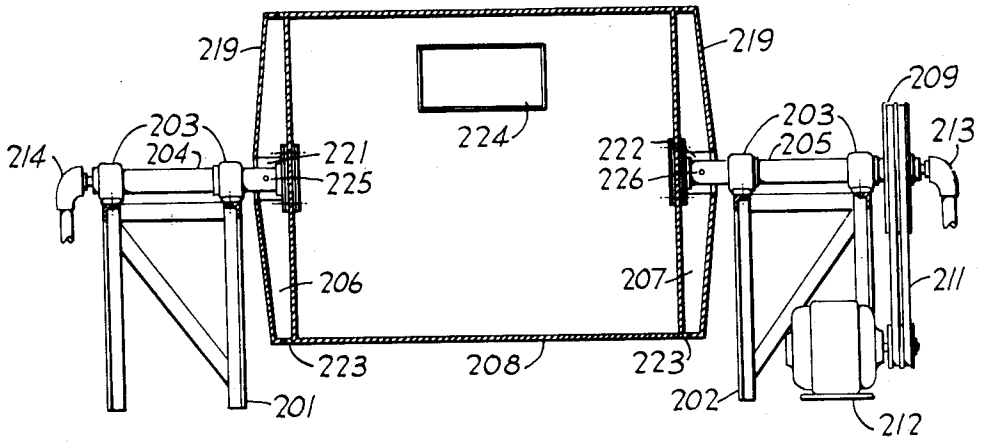
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FIG. 11



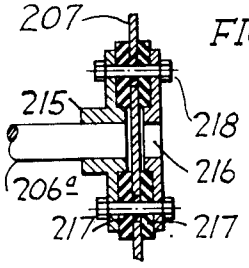


FIG 12

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UNITED STATES PATENT OFFICE

2,461,643

DYNAMIC BALANCER

George T. Hemmeter, Berkeley, Calif.

Application March 20, 1944, Serial No. 527,318

27 Claims. (Cl. 74—573)

1

This invention relates to rotating equipment such as, for example, the centrifugal baskets of domestic and commercial washing machines, centrifugal separators and filters, and centrifugal casting and molding machines.

One of the most serious difficulties encountered in operating equipment of this type results from the excessive vibration to which it is subjected, due to the fact that it is either inherently dynamically unbalanced or becomes so when non-uniformly loaded. In addition to being annoying, these vibrations result in the undue wear of the equipment.

In general, the object of this invention is the provision of an automatic dynamic balancer for rotary equipment.

More specifically, one of the objects of this invention is the provision of a frame; a rotor mounted on the frame for rotation about its own axis and for limited bodily movement with respect thereto in response to any substantial unbalancing dynamic force to which it may be subjected; a series of fluid receptacles carried by the rotor in spaced relation about its axis; and valve means associated with the rotor and responsive to any substantial bodily movement thereof for selectively establishing communication between at least one of the fluid receptacles and a point external thereto so that water or other fluid can be delivered to or discharged from at least one of the receptacles to thereby effect the dynamic balance of the rotor.

Another object of the invention is the provision of a rotor mounted on a frame in combination with means responsive to frame vibrations of a selected amplitude, for directly or indirectly controlling the rotor drive.

A further object of this invention is the provision of a clothes washing machine having a continuously self-balancing basket or spinner of novel construction.

A still further object of the invention resides in the provision of a clothes washing machine having a basket of novel construction for producing a more effective washing operation, and instrumental in effecting its own dynamic balance when used as a spinner.

The invention possesses other advantageous features, some of which with the foregoing will be set forth at length in the following description where those forms of the invention which have been selected for illustration in the drawings accompanying and forming a part of the present specification are outlined in full. In said drawings, six forms of the invention are shown, but it is to be understood that it is not limited to such forms, since the invention as set forth in the claims may be embodied in a plurality of forms.

Referring to the drawings:

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Figure 1 is a vertical mid section of a clothes washing machine embodying the objects of my invention and diagrammatically indicating the vibration responsive means for controlling the washing machine shaft-drive.

Figure 2 is a front elevation of the washing machine shown in Figure 1, with the right-hand portion thereof indicated in section to illustrate its construction more clearly.

Figure 3 is an enlarged vertical section of the basket, rotor or spinner of the machine shown in Figures 1 and 2.

Figure 4 is a fragmentary vertical section taken through the shaft and a portion of the spinner of the machine illustrated in Figures 1, 2 and 3, but showing the shaft radially displaced.

Figure 5 is a cross section taken on the section line 5—5 of Figure 4.

Figure 6 is a fragmentary vertical section of a washing machine provided with a modified form of balancing valve.

Figure 7 is a section taken on the line 7—7 of Figure 6.

Figure 8 is a fragmentary vertical section of a washing machine provided with still another form of balancing valve.

Figure 9 is a section taken on the line 9—9 of Figure 8.

Figure 10 is a section taken on the line 10—10 of Figure 8, but showing the shaft radially displaced.

Figure 11 is a mid-vertical section of the spinner and frame of a washing machine in which the spinner is supported at each end by trunnions journaled on the frame, each trunnion being provided with a balancing valve such as shown in Figures 4 and 5.

Figure 12 is an enlarged detail of the spinner hubs generally shown in Figure 11.

Preliminarily it may be said that I attain the automatic dynamic balance of a dynamically unbalanced body or rotor designed to rotate on a fixed axis at speeds at which centrifugal force becomes a factor, by taking advantage of the fact that the unbalancing force produces a couple tending to displace the axis of the rotor relative to the fixed axis on which it is designed to rotate. By so mounting the rotor on its frame that when in a dynamically unbalanced condition it is free for limited movement in response to the resulting unbalancing couple, this movement can be used directly or indirectly to control the operation of a fluid distributing valve. If then the rotor is provided with a series of fluid receptacles disposed in spaced relation about its axis, a distributing valve can be used to establish communication selectively between each of the fluid receptacles and a point or zone external thereto in order to change the quantity of water or other fluid contained therein. This exchange

of fluid to or from the selected fluid receptacle or receptacles will be maintained until the axis of the rotor coincides with the fixed axis on which it is designed to rotate when in dynamic balance. It is, of course, essential to effect the proper exchange of balancing fluid at such a zone or at such zones that it will result in a force and couple substantially counteracting the unbalancing force and couple, the exact location thereof depending upon whether the rotor is supported from both ends or cantilever fashion, only from one end. In the latter case, the exchange of the counterbalancing fluid must be at a zone substantially diametrically opposite the unbalancing force, whereas in the former case the proper exchange of balancing fluid can be made at two longitudinally spaced zones, one intersected by a transverse plane on one longitudinal side of the unbalancing force, and the other by a transverse plane on the opposed longitudinal side of the unbalancing force. The single resultant force and couple of the balancing fluid exchanged at these two spaced zones can be made substantially to counter-balance the resultant of the unbalancing forces and couples.

As shown in Figures 1 to 5 inclusive, the objects and principles of my invention have been embodied and applied to a domestic washing machine comprising a generally rectangular frame 1. Included as an integral part of the frame at the forward end thereof is a cylindrical shell 2 formed in its forward end with a circular port 3 and provided with a door 4. Bolted to the rear wall 5 of the shell 2 is a bearing support 6 in axial alignment with a complementary bearing support 7 mounted on a cross member 8 of the frame 1.

Journaled in the bearing support 6 through a bearing ring 9, and collar 10, is a sleeve 11 extending through an opening formed in the wall 5 and free to rotate on a predetermined fixed axis. Resiliently supported within the sleeve 11 for radial movement with respect thereto is a shaft 12, this being preferably accomplished by means of a rubber bushing 13 snugly accommodated within the sleeve and within which the shaft is snugly accommodated. The left-hand end of the bushing 13 is beveled and held in sealed relation against the shaft by means of a complementary retaining ring 14, the retaining ring being held against axial displacement on the shaft by a bead or shoulder 15 formed on the shaft 12. The right-hand end of the bushing 13 is undercut and held in sealed engagement with the inner surface of the sleeve 11 by a complementary retaining ring 16 formed on the left-hand end of a spacer sleeve 17 telescopically disposed within the sleeve 11. The bearing ring 9 is sealed within the annular space formed by the bearing support 6 and the collar 10 by a pair of spaced sealing rings 18 and 19. To further aid in sealing the left-hand end of the bushing 13 to the shaft, it is formed with an internal bead 20 adapted to seat in a channel 20a.

Fixed to the left-hand end of the shaft 12 for rotation therewith is a hub 21 and bolted to this hub is the back wall 22 of a generally cylindrical basket, rotor or spinner 23. The peripheral surface of the rotor 23 is provided with a plurality of peripherally spaced longitudinally extending and inwardly depressed portions 24, the interior surfaces of which serve as lifters for elevating and agitating clothes deposited within the rotor. The surface of the rotor intermediate the depressed portions 24 is perforated as at 25 for the purpose of permitting water to be forced therethrough during the drying operation of the machine, and through which water may enter and leave during the washing operation. Formed over and as a part of each of the depressed portions 24 is a longitudinally extending fluid receptacle 26 provided with a forwardly extending scoop 27. When the rotor is operating at slow speeds such as used for washing clothes, each of the scoops 27 serves to lift water from the shell 2 into an associated compartment 28 defined by each pair of adjacent fluid receptacles 26. The forward end 29 of the rotor is formed with an opening 30 in registration with the opening 3 of the shell 2. Communicating with each of the fluid receptacles 26 adjacent the rear wall 5 is a radially extending channel or conduit 31, the inner ends 32 of which terminate in a zone immediately surrounding the left-hand end of the sleeve 11. Formed in the sleeve 11 and in the bushing 13 are a plurality of registering ports 33 and 34 peripherally spaced about the sleeve, there being one set of these ports in alignment with each of the radial conduits 31.

The right-hand end of the shaft 12 is snugly fitted within a resilient rubber bushing 41, which in turn is snugly disposed within the sleeve 11. The left-hand end of the bushing 41 is under-cut and sealed against the inner surface of the sleeve 11 by the beveled end of the spacing sleeve 17. Intermediate the ends of the bushing 41 is a bead 42 accommodated within a groove 43 formed in the shaft 12, for further aiding to seal the bushing to the shaft. The right-hand end of the bushing 41 is beveled and sealed to the shaft by a threaded ring 44. Accommodated within the right-hand end of the sleeve 11 is a spacer ring 45, through which the shaft 12 passes with substantial positive clearance so as to be free for radial displacement therein. Similarly secured to the left-hand end of the sleeve 11 is a ring 46 through which the shaft also passes with sufficient positive clearance to enable it to move radially therein. The outer face of the ring 46 is polished and spherically curved, so as to be free to slide radially on the polished dished surface 47 formed on a boss 48 of the hub 21.

Slidably mounted on the shaft 12 are a pair of spaced pulley wheels 48 and 49 (see Figures 1 and 4) and splined to the shaft 12 intermediate these pulleys is a double-faced clutch disc 51 longitudinally movable in either direction and formed with a peripheral groove 52. Operatively associated with the clutch disc 51 is a fork 53 for engaging the clutch disc with the driving face of either of the pulleys 48 and 49.

Mounted on the frame 1 is an electric motor 61, to the shaft 62 of which is secured a pair of spaced pulley wheels 63 and 64 respectively in alignment with the pulleys 48 and 49 (see Figure 1). Reeved about the pulleys 48 and 63 is a belt 65 and reeved about the pulleys 49 and 64 is a belt 66.

Extending through the right-hand end of the shaft 12 is a bore 71 intersecting one or more transverse bores 72 formed in the shaft immediately to the right of the bushing 41. The right-hand end of the shaft is rotatably secured to a stationary fitting 73 for establishing communication between the bore 71 and a suitable source of fluid under pressure, such as water under city pressure.

From the above description, it will be observed that the sleeve 11 is arranged to be driven on a fixed axis with reference to the frame 1 at either

one of two speeds, and that the sleeve 11, bushing 13 and the shaft 12 are arranged for conjoint rotation. However, due to the resiliency of the bushing 13, the shaft 12 although always rotating at substantially the same speed as the sleeve 11 is free for limited radial displacement with respect to the sleeve. In other words, it is possible for the shaft 12 not only to rotate on its own axis, but also to rotate about the fixed axis of the sleeve 11, so that any point on the axis of the shaft will describe a closed path having the axis of the sleeve as its approximate center. If, therefore, the load such as the rotor, spinner or basket 23 and its associated parts carried by the shaft 12 is unbalanced or for any reason becomes unbalanced while the shaft is rotating at any such speed that centrifugal force is a factor, the rubber bushing 13 will permit the shaft 12 to be radially displaced in the direction of unbalance. Referring particularly to Figures 4 and 5, and assuming that at a given instant the point of unbalance of the rotor lies in a vertical plane passing through the axis of the shaft 12, the force acting on the shaft 12 will operate to displace the shaft radially downward and, therefore, compress the lower wall of the rubber bushing 13. Since the left-hand end of the bushing is sealed to the shaft, and the right-hand end is sealed to the sleeve, the downward displacement of the shaft will cause the upper surface of the shaft to part from the bushing, thereby establishing communication between the port 34 on the upper side of the sleeve and the annular space defined by the shaft 12 and the spacer sleeve 17 to the right of the bushing 13, and which for convenience in terminology may be designated as a fluid chamber or source of fluid under pressure 14. Water on other fluid under pressure, therefore, passes through the ports 33 and 34 and through their associated and aligned radial conduits 31 into its communicating fluid receptacle 26 diametrically opposite the point or zone of unbalance. This action continues until the water delivered to the fluid receptacle 26 substantially counterbalances the overload on the opposite side of the rotor and its associated parts, at which time the shaft 12 will become co-axial with the sleeve 11 and the bushing 13 will form an effective seal between the shaft and the sleeve. The sleeve 11, shaft 12 and the intervening resilient rubber bushing 13 may, therefore, be considered as a metering or balancing valve responsive to any substantial displacement of the shaft for establishing communication between a source of fluid pressure and a zone immediately surrounding the sleeve. In passing, it should be noted that although the bushing 13 should be sufficiently resilient to be compressed under the action of an unbalanced centrifugal force, it should nevertheless be sufficiently rigid to support the shaft 12 co-axially with the sleeve 13 against the mere weight of the shaft, the rotor and its associated parts when rotating at relatively slow speeds.

Since the automatic valve above referred to is not instantaneously operative to balance the rotor, and since the rotor and frame will vibrate so long as an out of balance condition prevails, it may be desirable to bring the rotor up to speed gradually during the balancing operation, in order to avoid vibrations of an amplitude greater than a predetermined tolerance. As illustrative of means for accomplishing this result, I have diagrammatically illustrated in Figure 1 an electric circuit designed intermittently to interrupt the motor power line in response to vibrations of the frame f of a selected amplitude.

In general, this circuit contains three basic elements—an inertia switch generally designated by the reference numeral 81, a double pole solenoid switch generally designated by the reference numeral 91, and a thermostatic switch generally designated by the reference numeral 95, all incorporated in a casing 80 mounted as shown in Figure 2 to the frame f.

The inertia switch 81 comprises a weight 81*a* adjustably carried on a spring arm 81*b* supported in any desired manner by the casing 80. Operatively associated with the spring arm 81*b* is a screw 81*c* for placing the spring arm 81*b* under any predetermined tension, and thereby aiding in controlling its period of vibration. Carried by the spring arm 81*b* is a soft spring finger 81*d*, provided at its lower end with a contact 81*e*, and associated with this contact in alignment therewith is an adjustable contact 81*f*. Since the inertia switch 81 is mounted in the casing 80, which in turn is carried by the frame f, any vibrations to which the frame f is subjected will be transmitted to the contact 81*f*, and consequently the movement of the contact 81*f* in response to the vibration of the frame f will operate to bring the contact 81*f* into engagement with the relatively stationary contact 81*e*. The spring finger 81*d* should be softer than the spring arm 81*b*, so as to permit the contact 81*f* to engage the contact 81*e* during a substantial period of time. By suitably locating the weight 81*a* on the spring arm 81*b*, and by properly adjusting the tension on the spring arm 81*b* by means of the screw 81*c*, the period of vibration of the spring arm 81*b* and its associated weights 81*a* can be made different from that of the period of vibration of the frame f, so as to insure that these two members will not vibrate in synchronism.

The solenoid switch 91 comprises a coil 91*a*, a pair of opposed poles 91*b*, and 91*c*, a common contact member 91*d*, and a resistor 91*e*.

The thermostatic switch 95 comprises a pair of poles 95*a*, and 95*b*, a temperature responsive member 95*c*, and a heating element 95*d* shunted across the poles 95*a* and 95*b*.

Normally the motor 61 is connected with the two legs 96 and 97 of the power line, in series with the pole 91*b*, the common contact member 91*d*, which is normally closed on the pole 91*b*, and a fluid pressure responsive switch 98. This latter switch is designed to close only in response to the pressure on the water line delivering water to the shaft of the rotor through the fitting 73, and is used simply as a precautionary measure. The inertia switch 81 is shunted across the power line in series circuit with the solenoid 91*a* and the resistor 91*e*. Consequently if the frame f vibrates at an amplitude greater than a predetermined selected amplitude, the contact 81*f* will be brought into engagement with the relatively stationary contact 81*e*, thereby closing the solenoid coil 91*a*. The energization of the coil 91*a* operates to close the common contact member 91*d* against the pole 91*c*, whereupon the motor circuit is opened and the coil 91*a* is placed directly across the line in series with the resistor 91*e*. However, it is to be observed that when the common contact member 91*d* is closed on the pole 91*c*, the heating element 95*d* is also placed directly across the power line in series with the resistor 91*e*. The heat devel-

oped by the element 95d, therefore, serves to close the contact 95c on the poles 95a and 95b, thereby short-circuiting the solenoid coil 91a, and in turn permitting the common contact member 91d to engage the pole 91b and to close the motor circuit. As is well known, the thermostatic switch 95, one form of which is known by the trade name "Flasher Button," can be designed to operate intermittently on any predetermined selected cycle.

The circuit above described, therefore, intermittently serves to interrupt the shaft drive so long as the rotor is out of dynamic balance to such an extent that the frame 1 is caused to vibrate at an amplitude greater than a predetermined selected amplitude. This is of considerable importance, for since the magnitude of the unbalancing force varies as the square of the speed of rotation of the shaft, the shaft should preferably be brought up to its normal spinning speed only at the same rate at which the metering valves are able to bring about the substantial dynamic balance of the rotor.

Obviously the same or a similar circuit can be used intermittently to operate a solenoid for actuating the clutch fork 53, and thereby mechanically controlling the shaft drive.

In passing, it might be well to observe that any water delivered to the fluid receptacles 26 is retained on the peripheral portions thereof by centrifugal force so long as the rotor is rotating at any appreciable speed, and that when the speed of the rotor falls below this point, the water is free to drain downwardly through the conduits 31, where it will impinge on the outer end of the sleeve 11 and eventually find its way into the shell 2.

In Figures 6 and 7, a modified automatic valve has been illustrated, comprising a sleeve 101 bolted to the frame 102, such as part of the frame of a washing machine as shown in Figure 1. Snugly fitted within the sleeve 101 is a rubber bushing 103 formed at each end with outwardly extending necks 104. Snugly fitted within the bushing 103 is a bearing sleeve 105, and journaled in this sleeve is a shaft 106. The longitudinally opposed peripheral edges 107 of the bushing 103 are sealed to the sleeve 101 by rings 108 screwed to the ends of the sleeve, these rings being provided with central openings 109 having a diameter substantially greater than the outer diameter of the necks 104. Each of the necks 104 is sealed to the bearing sleeve 105 by rings 111. Formed around the inner surface of the sleeve 101 is a channel 112, communication between this channel and the source of fluid under pressure being established by a conduit 113. Formed around the outer periphery of the bearing sleeve 105 is a channel 114, communicating through one or more passageways 115 with the channel 112. Extending through the sleeve 101 and the bushing 103 are a plurality of sets of aligned ports 116 and 117.

Secured to the left-hand end of the shaft 106 is a hub 118 and bolted to this hub is the back plate of the rotor, spinner or basket 119 of a washing machine, constructed in the same manner as illustrated in Figures 1 to 4 inclusive, and provided with fluid receptacles and with radial conduits 121 communicating therewith.

The right-hand end of the shaft 106 is journaled in a bracket 122 bolted to the frame 102, and has secured to it a pulley wheel 123.

In this modification, the sleeve 101, bushing 103 and bearing sleeve 105 are non-rotatably secured to the frame 102. The shaft 106 rotates within the bearing sleeve 105, and due to the resiliency of the rubber bushing 103, the shaft and the bearing sleeve 105 can be displaced radially in response to any unbalanced condition prevailing in the rotor or other load carried by the shaft. Assuming that at any given instant under consideration the shaft is being pulled downwardly by an unbalanced condition of the load which it carries, the lower portion of the bushing 103 will be compressed, thereby permitting the upper surface of the balancing sleeve 105 to pull away from the adjacent surface of the bushing. Water under pressure may then pass from the channel 114 (which for convenience in terminology may be considered as a source of liquid under pressure) through the gap between the bushing and the sleeve and through the aligned ports 116 and 117 to a point immediately adjacent the lower end of the conduit 12. From this point, the water is picked up by the conduits 121 and carried by centrifugal force to the fluid receptacle with which the conduit 121 is associated. As in the case of the modification shown in Figures 1 to 5 inclusive, this operation will continue until the water so added to the fluid receptacle in question is sufficient to substantially dynamically balance the over-load disposed on the opposite side of the rotor. When a substantially dynamically balanced condition has been obtained, the shaft and bearing sleeve 105 will assume their normal co-axial position with the sleeve 101. Although strictly speaking the shaft when not in dynamic balance oscillates or gyrates about the center of its right-hand bearing, for all practical purposes the movement of the shaft can be considered as radial.

In Figures 8, 9 and 10, still another form of automatic valve responsive to the radial displacement of a shaft has been illustrated. In this modification, a sleeve 151 is mounted on a frame 152 for rotation on a fixed axis. Snugly disposed within the sleeve 151 is a resilient rubber bushing 152a. Snugly disposed within this bushing is a shaft 153, provided with a pair of spaced collars 154 and 156 for holding the bushing against longitudinal displacement. The right-hand end of the sleeve 151 terminates in a transverse wall 157 provided with a plurality of ports 158 extending therethrough and disposed in spaced relation about its own axis. Formed in the transverse wall 157 is an opening 158 through which the shaft 153 extends with substantial positive clearance, and secured to the left-hand end of the shaft is a hub 159. Bolted to this hub is the rotor, spinner or basket 161 of a washing machine provided with radial conduits 162 and otherwise constructed in substantial accordance with the rotor illustrated in Figures 1 to 4 inclusive.

The inner face of the hub 159 is provided with a boss having a ground dished bearing surface 163 for engagement with the complementary surface of the outer end of the transverse wall 157. Slidably disposed on the shaft 153 adjacent to transverse wall 157 is an inwardly flanged valve closure member 164. Disposed within the flange 164 is a gasket 165 and a bearing ring 167. Surrounding the shaft is a compression spring 168 having one end in abutment with the bearing ring 167, and the other end with the collar 154. The spring 168, therefore, serves to hold the valve closure member 164 resiliently against the ported transverse wall 157, and to effectively seal the bushing 165 to shaft 153 and valve 164.

The right-hand end of the sleeve 151 is rotatably mounted on a portion of the frame 152 through a bearing 169, and snugly fitted within the right-hand end of the sleeve 151 is a rubber bushing 172. Disposed and secured in this bushing is a right-hand end of the shaft 153.

Rotation is imparted to the sleeve 15 and its associated parts by a pulley 173 journaled on the end of the shaft adjacent a thrust collar 174 secured to the sleeve 151, and arranged to frictionally engage a clutch disc 175 splined to the shaft. Axial movement of the clutch disc 175 is effected through a fork and lever in the same manner as described in connection with the clutch disc 51 illustrated in Figure 4.

In this modification, the sleeve 151, the bushing 152a and the shaft 153 are arranged for conjoint rotation, although due to the resiliency of the bushings 152a and 172 the shaft is free for radial displacement within the sleeve. Assuming that at any given instance under consideration the shaft is dynamically unbalanced in the downward direction, it will be observed, as illustrated in Figures 9 and 10, that the shaft will be displaced radially downward carrying with it the valve closure member 164. The relative movement between the valve closure member 164 and the transverse wall 157 serves to open one or more of the upper ports 156, thereby establishing communication between the annular space in which the spring 168 is accommodated and a zone immediately surrounding the left-hand end of the sleeve 151. The water passing through the port or ports 158 is then conducted through the adjacent conduits 162, to the fluid receptacles of the rotor associated with these conduits. Here again this action prevails until the water so introduced into the fluid receptacles is sufficient to counter-balance the over-load on the opposite side of the rotor, and to bring the unit into substantial dynamic balance.

The annular space defined by the shaft 153 and the sleeve 151, in which the spring 168 is accommodated, for convenience in terminology may be considered as a source of fluid under pressure. Communication between this chamber and an ultimate source of fluid under pressure may be established by providing a plurality of holes 176 in the bushing 152a, forming the right-hand end of the shaft 153 with a bore 177, and the intermediate portion of the shaft with a transverse bore 178 intersecting the bore 177.

The automatically self-balancing unit illustrated in Figures 11 and 12 comprises frame members 201 and 202, each provided with spaced bearing supports 203. Journaled in these supports are axially aligned sleeves 204 and 205, and resiliently mounted in each of these sleeves in the same manner as illustrated in Figures 4 and 5 is a trunnion or shaft 206a for supporting the opposed heads 206 and 207 of a spinner or rotor 208. The right-hand trunnion of the shaft is driven by pulleys 209, belts 211 and a motor 212, and water is introduced into each shaft by fittings 213 and 214.

As shown in detail in Figure 12, the drum head 207 is resiliently mounted to its associated trunnion or shaft 206a through a hub 215 to which it is keyed. Disposed on both sides of the drum head in alignment with the hub 215 and an opposed ring 216 are rubber washers 217, the hub, washers and rings being fastened together by bolts 218.

Formed on each end of the rotor 208 are a series of radially disposed fluid conduits and receptacles 219 terminating at their inner ends in annular zones 221 and 222. The peripheral wall of each of the receptacles 219 is formed with a small drain opening 223, and the rotor with a loading port or gate 224. Like the sleeve 11 shown in Figure 4, the sleeves 204 and 205 are formed with a series of ports 225 and 226 located respectively within the zones 221, each in radial alignment with one of the combined conduits and fluid receptacles 219, and each substantially larger than the drain openings 223.

Although the balancing or metering valves associated with the sleeves 204 and 205 are identical with the metering valve shown in Figure 4, the present unit differs in two essentials from the units previously described. In the first place, the rotor is supported at both ends rather than only from one end, and in the second place, it is provided at both ends with a balancing or metering valve, and the balancing fluid is applied at points to the left and right of the rotor proper, rather than substantially diametrically opposite the point or zone of unbalance as in the case with a rotor supported only at one end. The dynamic balance of the unit by this method is possible for the reason that the resultant of the unbalancing forces acting on the rotor can be balanced by a balancing force on either side of the unbalancing force, that is, by two longitudinally spaced balancing forces.

Obviously this unit, as well as each of the other modifications described, can be provided as illustrated in Figure 1, with a vibration response switch mechanism for preventing the rotor from coming up to full speed so long as it tends to vibrate excessively due to an unbalanced condition. Whenever such a device is used, it is, of course, essential that the frame of the unit be so mounted on its base that it is free for limited vibration. This can be done, for example, by either mounting the unit on castors, as shown in Figures 1 and 2, or by mounting it on resilient blocks.

Although in Figures 1 and 2, the rotor is illustrated as revolving about an inclined axis in order to obtain a tumbling of the clothes contained in the rotor in two planes rather than in only one, this disposition of the axis of rotation of the spinner is by no means essential to the operation of the self-balancing feature of this invention, for in so far as this feature is concerned, the direction of the rotor axis is immaterial.

In recapitulation it may be observed that to attain a dynamically self-balancing unit in accordance with the present invention, three essential conditions must be met. The rotor must be so mounted on its frame that it is free for limited bodily movement or displacement with respect to the predetermined fixed axis on which it is designed to rotate when substantially in dynamic balance. Fluid receptacles must be associated with the rotor for rotation therewith, and located in spaced relation about its axis and in such a transverse plane or planes that the proper addition of fluid to or from one or more of them will bring about the dynamic balance of the rotor. And valve means must be provided, operative in response to any substantial bodily movement or displacement of the rotor, for selectively establishing communication between one or more of the fluid receptacles and a point external thereto for either adding water thereto or discharging water therefrom.

Although in the drawings several types of distributing valves have been illustrated, and several

different methods of mounting the rotor, so that it is free for limited bodily movement, these by no means exhaust the number of structures which can be made in accordance with the three conditions enumerated above, and which will serve substantially to balance dynamically a rotor and maintain it in such balance even though the unbalancing force changes from time to time.

In the above specification, the term "fluid" has been used in a broad sense to designate any material which can be made to flow readily, and includes materials such as sand, as well as liquids. While sand might not be suitable in connection with equipment such as washing machines, it might be very effective in connection with centrifugal molding and casting equipment. The term "source of fluid under pressure" has been used to designate any point associated with a rotor or its frame at which such a fluid is or can be made available. The term "rotor" has been used in a broad sense to designate any body arranged to rotate at such speeds that centrifugal force becomes a factor irrespective of the specific function of the body.

I claim:

1. A dynamically self-balancing unit comprising: a frame; a rotary shaft resiliently mounted on said frame for balanced rotation about a fixed axis but free for resiliently restricted radial displacement with respect thereto; resilient means for constraining said shaft to rotate on said fixed axis; a body fixed to said shaft for rotation therewith and provided with fluid receptacles disposed in spaced relation about its axis; a source of fluid under pressure associated with said frame; and valve means supported by said frame and responsive to any substantial radial displacement of said shaft for establishing communication selectively between said source of fluid and at least one of the receptacles on that side of the shaft opposite the direction of its displacement.

2. A dynamically self-balancing unit comprising: a frame; a sleeve mounted on said frame; a shaft mounted within said sleeve co-axially therewith; resilient means for constraining said shaft to rotate on the axis of said sleeve; a body fixed to said shaft adjacent one end of said sleeve; fluid receptacles carried by said body in spaced relation about its axis; conduits carried by said body establishing communication between said receptacles and a zone adjacent said sleeve; a source of fluid under pressure carried by said frame; and valve means associated with said shaft and responsive to any radial displacement thereof for establishing communication between said fluid source and that side of said zone opposite the direction of displacement of said shaft.

3. A dynamically self-balancing unit comprising: a frame; a sleeve supported by said frame on a fixed axis with reference thereto; a resilient bushing disposed within said sleeve; a shaft supported within said bushing for balanced rotation therein about said fixed axis; a body fixed to said shaft for rotation therewith and provided with fluid receptacles disposed in spaced relation about its axis; a source of fluid under pressure carried by said frame; and a valve means supported by said frame and responsive to any substantial radial displacement of said shaft with reference to said fixed axis for establishing communication selectively between said source of fluid and at least one of said receptacles on that side of the shaft opposite the direction of its displacement, and in line with the unbalanced load.

4. A dynamically self-balancing unit comprising: a frame; a sleeve supported by said frame on a fixed axis with reference thereto; a resilient bushing disposed within said sleeve; a shaft supported within said bushing for balanced rotation therein about said fixed axis; a body fixed to said shaft for rotation therewith and provided with fluid receptacles spaced about said shaft; means establishing communication between each of said receptacles and a zone immediately surrounding said sleeve; a fluid chamber surrounding said shaft; and valve means interposed between said fluid chamber and said zone responsive to any substantial radial displacement of said shaft for establishing communication between said fluid chamber and said zone.

5. A dynamically self-balancing unit comprising: a frame; a shaft mounted on said frame for rotation about its own axis and for limited bodily radial movement with reference to said frame; resilient means for constraining said shaft to rotate about a fixed axis; a rotor fixed to said shaft; fluid receptacles carried by said rotor in spaced relation about its axis; valve means associated with said shaft and responsive to bodily movement thereof for selectively establishing communication between at least one of said fluid receptacles and a point external thereto; power means for driving said rotor; and vibration responsive means associated with said frame for controlling said power means.

6. A dynamically self-balancing unit comprising: a frame; a rotary shaft mounted on said frame for balanced rotation about a fixed axis but free for radial displacement with respect thereto; resilient means for restraining said shaft to rotate on said fixed axis; a body fixed to said shaft for rotation therewith and provided with fluid receptacles disposed in spaced relation about its axis; a source of fluid under pressure associated with said frame; valve means supported by said frame and responsive to any substantial radial displacement of said shaft for establishing communication selectively between said source of fluid and at least one of the receptacles on that side of the shaft opposite the direction of its displacement; a motor for driving said shaft and means responsive to vibrations of predetermined amplitudes for interrupting said motor.

7. A dynamically self-balancing unit comprising: a frame; a sleeve mounted on said frame; a shaft mounted within said sleeve co-axially therewith; resilient means for constraining said shaft to rotate on the axis of said sleeve; a body fixed to said shaft adjacent one end of said sleeve; fluid receptacles carried by said body in spaced relation about its periphery; conduits carried by said body establishing communication between said receptacle and a zone adjacent said sleeve; a source of fluid under pressure carried by said frame; valve means associated with said shaft and responsive to any radial displacement thereof for establishing communication between said fluid source and that side of said zone opposite the direction of displacement of said shaft; a motor for driving said rotor; and vibration responsive means carried by said frame for controlling said motor.

8. A dynamically self-balancing unit comprising: a frame; a sleeve mounted on said frame; a shaft mounted within said sleeve for rotation about its own axis and for limited radial displacement with respect to the axis of said sleeve; resilient means for constraining said shaft to rotate on the axis of said sleeve; a body fixed to said shaft adjacent one end of said sleeve; fluid receptacles carried by said body in spaced relation

about its periphery; conduits carried by said body establishing communication between said receptacle and a zone adjacent said sleeve; a source of fluid under pressure carried by said frame; valve means associated with said shaft and responsive to any radial displacement thereof for establishing communication between said fluid source and that side of said zone opposite the direction of displacement of said shaft; a motor mounted on said frame for driving said rotor; and means responsive to vibrations of a selected amplitude for controlling said motor.

9. A dynamically self-balancing unit comprising: a frame; a sleeve journaled in said frame for rotation on a fixed axis with respect thereto; a shaft resiliently mounted within said sleeve for conjoint rotation therewith, said shaft being free to rotate on its own axis and simultaneously about said fixed axis; resilient means for constraining said shaft to rotate on said fixed axis; a body fixed to said shaft for rotation therewith and provided with fluid receptacles disposed in spaced relation about its periphery; a fluid chamber surrounding said shaft; and valve means associated with said shaft and sleeve responsive to any substantial radial displacement of said shaft for establishing communication selectively between said fluid chamber and at least one of said receptacles on that side of said shaft opposite the direction of its displacement.

10. A dynamically self-balancing unit comprising: a frame; a sleeve journaled in said frame for rotation on a fixed axis with respect thereto; a resilient bushing secured within and to said sleeve for rotation therewith; a shaft snugly disposed within said bushing for conjoint rotation with said sleeve and bushing; a body fixed to said shaft and provided with fluid receptacles disposed in spaced relation about its own axis; conduits carried by said body for establishing communication between each of said receptacles and a zone surrounding said sleeve; a fluid chamber surrounding said shaft; and valve means surrounding said shaft and responsive to any substantial radial displacement thereof relative to said fixed axis for establishing communication between said fluid chamber and that side of said zone opposite the direction of displacement of said shaft.

11. A dynamically self-balancing unit comprising: a frame; a sleeve journaled in said frame for rotation on a fixed axis with respect thereto; a resilient bushing snugly fitted within said sleeve, said sleeve and bushing being provided with peripherally spaced registering ports extending therethrough; a shaft snugly fitted within said bushing; means for securing one end of said bushing to said sleeve and means for securing the opposite end of said bushing to said shaft; a source of fluid under pressure adjacent the former end of said bushing; a body secured to said shaft on the opposite side of said bushing; fluid receptacles carried by said body in spaced relation about its own axis; and conduits carried by said body establishing communication between said receptacles and a zone surrounding the ports in said sleeve.

12. A dynamically self-balancing unit comprising: a frame; a sleeve journaled in said frame for rotation on a fixed axis with respect thereto; a resilient bushing secured within and to said sleeve for rotation therewith; a shaft snugly disposed within said bushing for conjoint rotation with said sleeve and bushing; a body fixed to said shaft and provided with fluid receptacles disposed in spaced relation about its own axis; conduits carried by said body for establishing communication between each of said receptacles and a zone surrounding said sleeve; a fluid chamber surrounding said shaft; valve means surrounding said shaft and responsive to any substantial radial displacement thereof relative to said fixed axis for establishing communication between said fluid chamber and that side of said zone opposite the direction of displacement of said shaft.

13. A dynamically self-balancing unit comprising: a frame; a sleeve supported by said frame and provided with peripherally spaced ports extending through its walls; a resilient bushing snugly fitted within said sleeve; a shaft extending through and supported by said bushing; a rotor fixed to said shaft and provided with fluid receptacles disposed in spaced relation about its axis and with conduits establishing communication between said receptacles and said ports; a fluid chamber circumscribing said shaft adjacent said ports; and valve means responsive to a radial displacement of said shaft with respect to the axis of said sleeve for selectively establishing communication between said fluid chamber and at least one of said ports opposite the direction of displacement of said shaft.

14. A dynamically self-balancing unit comprising: a frame; a sleeve carried by said frame and provided with a transverse interior valve seat, said seat being formed with a series of ports spaced about the axis of said sleeve establishing communication between the interior and exterior of said sleeve; a shaft mounted within said sleeve for radial displacement therein and extending through said valve seat with substantial positive clearance; resilient means for constraining said shaft to rotate on the axis of said sleeve; a valve closure disc mounted on said shaft and seated against said valve seat, said valve seat having an external diameter substantially smaller than the internal diameter of said sleeve and being arranged to slightly overlap all of said ports only when said shaft and said sleeve are co-axial; a rotor fixed to said shaft and provided with fluid receptacles disposed in spaced relation about its axis; conduits establishing communication between said receptacles and the outer ends of the ports in said sleeve; and means for introducing fluid under pressure to a point within said sleeve adjacent said valve closure disc.

15. A dynamically self-balancing unit comprising: a frame; a shaft mounted on said frame for rotation about its own axis and for limited bodily movement with respect to a fixed axis; resilient means for constraining said shaft to rotate about said fixed axis; a rotor rigidly secured to said shaft co-axially therewith; fluid receptacles carried by said rotor in spaced relation about its periphery; a source of fluid under pressure carried by said frame; and valve means carried by said frame and responsive to any gyratory movement of said shaft selectively for establishing communication between said source of fluid and at least one of said fluid receptacles.

16. A dynamically self-balancing unit comprising: a frame; a shaft mounted on said frame for rotation about its own axis and for limited bodily movement with respect to a fixed axis; resilient means for constraining said shaft to rotate about said fixed axis; a rotor rigidly secured to said shaft co-axially therewith; fluid receptacles carried by said rotor in spaced relation about its periphery; a source of fluid under pressure carried by said frame; and valve means carried by

said frame for rotation with said shaft and selectively for establishing communication between said source of fluid and at least one of said fluid receptacles.

17. A dynamically self-balancing unit comprising: a frame; a rotary shaft mounted on said frame for rotation about its own axis and for limited radial displacement with respect to a fixed axis; resilient means for constraining said shaft to rotate about said fixed axis; a body fixed to said shaft for rotation therewith and provided with fluid receptacles disposed in spaced relation about its periphery; a source of fluid under pressure associated with said frame; and valve means associated with said shaft and responsive to any substantial radial displacement thereof selectively for establishing communication between said source of fluid and at least one of said receptacles on that side of the shaft opposite the direction of its displacement.

18. In a centrifuge, a frame, an apertured mounting member carried by said frame, a container, means supporting the container on the frame and permitting radial movement of said container relative to said mounting member, means for rotating the container, fluid balancing pockets on said container and a source of fluid for said pockets, valve means including a rubber-like sleeve element and a cooperating sealing element, said elements having normally engaged sealing surfaces that block communication between said fluid source and said pockets, the sealing surfaces of said elements having an extent in the direction of the axis of rotation, one of said elements mounted to move radially with said container and the other mounted to move radially with said mounting member, radial unbalance of said container during rotation thereof causing relative radial motion of said container and mounting member and separation of the normally engaged sealing surfaces of said elements, said sealing surfaces when separated defining a fluid passageway communicating with said source of fluid and at least one balancing pocket on said container.

19. In a centrifuge, a frame, an apertured mounting member carried by said frame, a container, means supporting the container on the frame, said means preventing substantially all axial motion of points on said container relative to said mounting member and permitting radial movement of said container relative to said mounting member, means for rotating the container, fluid balancing pockets on said container and a source of fluid for said pockets, valve means including a rubber-like sleeve element and a cooperating sealing element, said elements having normally engaged sealing surfaces that block communication between said fluid source and said pockets, the sealing surfaces of said elements having an extent in the direction of the axis rotation, one of said elements mounted to move radially with said container and the other mounted to move radially with said mounting member, radial unbalance of said container during rotation thereof causing relative radial motion of said container and mounting member and separation of the normally engaged sealing surfaces of said elements, said sealing surfaces when separated defining a fluid passageway communicating with said source of fluid and at least one balancing pocket on said container.

20. In a centrifuge, a frame, an apertured mounting member carried by said frame, a container, means connected between the container and the frame to prevent substantially all axial motion of said container and points thereon relative to said mounting member, said means permitting radial movement of said container, fluid balancing pockets on said container and a source of fluid for said pockets, valve means including a rubber-like sleeve element and a cooperating sealing element, said elements having normally engaged sealing surfaces that block communication between said fluid source and said pockets, the sealing surfaces of said elements having an extent in the direction of the axis of rotation, one of said elements mounted to move radially with said container and the other mounted to move radially with said mounting member, radial unbalance of said container during rotation thereof causing relative radial motion of said container and mounting member and separation of the normally engaged sealing surfaces of said elements, said sealing surfaces when separated defining a fluid passageway communicating with said source of fluid and at least one balancing pocket on said container.

21. In a centrifuge, a frame, an apertured mounting member carried by said frame, a container, shaft means mounted in said frame and connected to rotate the container, said shaft means preventing substantially all axial motion of said container and points thereon relative to said mounting member, fluid balancing pockets on said container and a source of fluid for said pockets, valve means including a rubber-like sleeve element and a cooperating sealing element, said elements having normally engaged sealing surfaces that block communication between said fluid source and said pockets, the sealing surfaces of said elements having an extent in the direction of the axis of rotation, one of said elements mounted to move radially with said container and the other mounted to move radially with said mounting member, the mounting of said shaft means in the frame being relatively remote from said valve means so that the container can move radially relative to said mounting member by flexing of the shaft means, radial unbalance of said container during rotation thereof causing said shaft means to flex to produce relative radial motion of said container and mounting member and separation of the normally engaged sealing surfaces of said elements, said sealing surfaces when separated defining a fluid passageway communication with said source of fluid and at least one balancing pocket on said container.

22. In a centrifuge, a frame, an apertured mounting member carried by said frame, a container, shaft means mounted in said frame and connected to rotate the container, said shaft means extending through said mounting member, fluid balancing pockets on said container and a source of fluid for said pockets, valve means including a rubber-like sleeve element mounted between said mounting member and said shaft means and a sealing element cooperating with said sleeve element, said elements having normally engaged sealing surfaces that block communication between said fluid source and said pockets, the sealing surfaces of said elements having an extent in the direction of the axis of rotation, one of said elements mounted to move radially with said shaft means and the other mounted to move radially with said mounting member, radial unbalance of said container during rotation thereof causing radial motion of said shaft means relative to said mounting member to separate the normally engaged sealing surfaces of

said elements, said sealing surfaces when separated defining a fluid passageway communicating with said source of fluid and at least one balancing pocket on said container.

23. In a centrifuge, a frame, an apertured mounting member carried by said frame, a container, shaft means mounted in said frame and connected to rotate the container, said shaft means extending through said mounting member and fluid balancing pockets on said container and a source of fluid for said pockets, valve means including a rubber-like sleeve element mounted between said mounting member and said shaft means, a sealing element cooperating with said sleeve element, said elements having normally engaged sealing surfaces that block communication between said fluid source and said pockets, the sealing surfaces of said elements having an extent in the direction of the axis of rotation, one of said elements mounted to move radially with said shaft means and the other mounted to move radially with said mounting member, the mounting of said shaft means in the frame being relatively remote from said valve means so that the shaft means can move radially relative to said mounting member by flexing of the shaft means, radial unbalance of said container during rotation thereof causing said shaft means to flex relative to said mounting member to separate the normally engaged sealing surfaces of said elements, said sealing surfaces when separated defining a fluid passageway communicating with said source of fluid and at least one balancing pocket on said container.

24. In a centrifuge, a frame, an apertured mounting member carried by said frame, a container, shaft means mounted in said frame and connected to rotate the container, said shaft means extending through said mounting member, fluid balancing pockets on said container, a source of fluid for said pockets, valve means including a rubber-like sleeve element supported by said mounting member, a sealing element carried by said shaft means cooperating with said sleeve element, said elements having normally engaged sealing surfaces that block communication between said fluid source and said pockets, the sealing surfaces of said elements having an extent in the direction of the axis of rotation, radial unbalance of said container during rotation thereof causing radial motion of said shaft means relative to said mounting member and separation of the normally engaged sealing surfaces of said elements, said sealing surfaces when separated defining a fluid passageway communicating with said source of fluid and at least one balancing pocket on said container.

25. In a centrifuge, a frame, an apertured mounting member carried by said frame, a container, shaft means mounted in said frame and connected to rotate the container, said shaft means extending through said mounting member and fluid balancing pockets on said container and a source of fluid for said pockets, valve means including a rubber-like sleeve element supported by said mounting member, a sealing element carried by said shaft means cooperating with said sleeve element, said elements having normally engaged sealing surfaces that block communication between said fluid source and said pockets, the sealing surfaces of said elements having an extent in the direction of the axis of rotation,

the mounting of said shaft means in the frame being relatively remote from said valve means so that the sealing element on the shaft means can move radially relative to said mounting member by flexing of the shaft means, radial unbalance of said container during rotation thereof causing said shaft means to flex relative to said mounting member and separation of the normally engaged sealing surfaces of said elements, said sealing surfaces when separated defining a fluid passageway communicating with said source of fluid and at least one balancing pocket on said container.

26. In a centrifuge, a frame, an apertured mounting member carried by said frame, a container, shaft means mounted in said frame and connected to rotate the container, said shaft means extending through said mounting member, fluid balancing pockets on said container, a source of fluid for said pockets, valve means including a rubber-like sleeve element supported by said mounting member, sealing means comprising a bushing element rotatably supported by said shaft means, said elements having normally engaged sealing surfaces that block communication between said fluid source and said pockets, the sealing surfaces of said elements having an extent in the direction of the axis of rotation, radial unbalance of said container during rotation thereof causing radial motion of said shaft means and bushing element relative to said mounting member and separation of the normally engaged sealing surfaces of said elements, said sealing surfaces when separated defining a fluid passageway communicating with said source of fluid and at least one balancing pocket on said container.

27. A dynamically self-balancing unit comprising: a frame; a sleeve mounted on said frame for rotation on a fixed axis; a shaft mounted within said sleeve for radial displacement therein; resilient means for constraining said shaft to rotate on the axis of said sleeve; a rotor fixed to said shaft for conjoint rotation with said sleeve and shaft and provided with fluid receptacles carried by said rotor disposed in spaced relation about the axis of said rotor; a fluid chamber within said sleeve; and valve means associated with said sleeve and shaft for establishing communication selectively between said fluid chamber and at least one of said fluid receptacles, said valve including a pair of cooperating members radially slidable over each other, one being fixed to said shaft and the other to said sleeve.

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