Aug. 31, 1965 P. FAVROT 3,203,273

UNBALANCE COMPENSATOR

Filed April 5, 1963

Fig. 1.

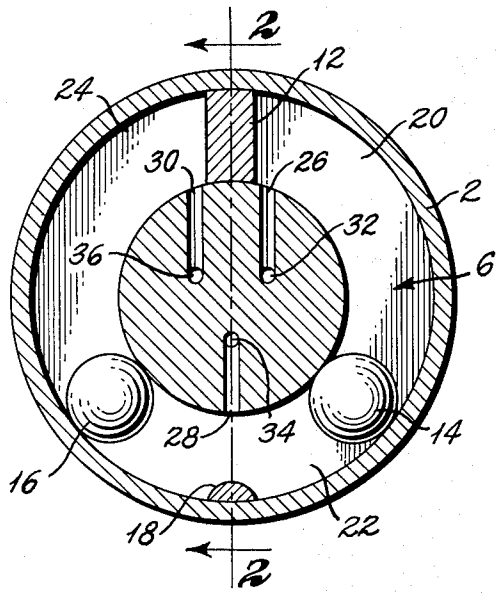


Fig. 4.

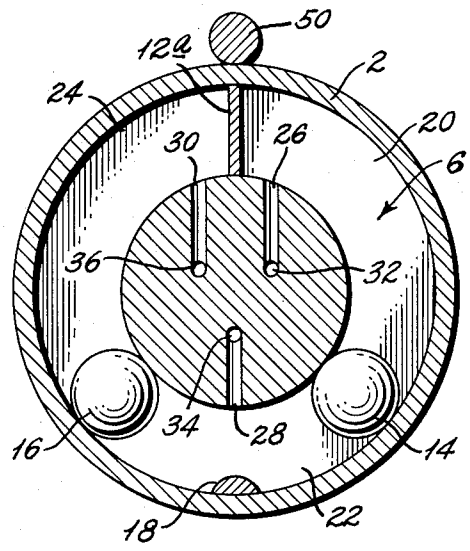


Fig. 2.

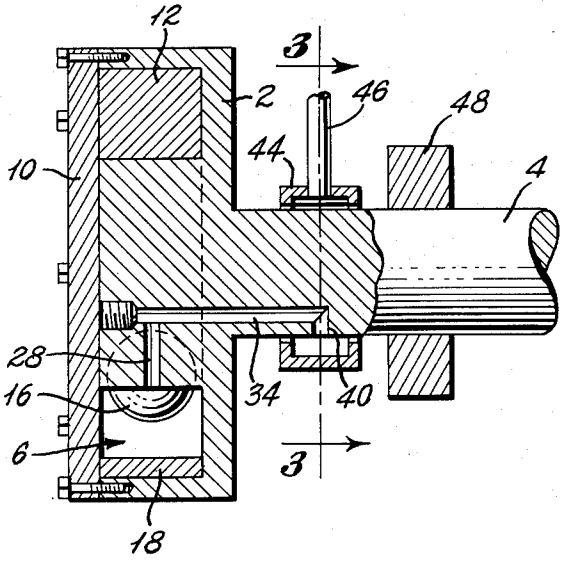
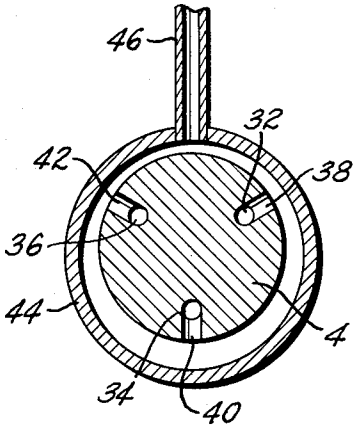


Fig. 3.



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UNBALANCE COMPENSATOR

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8 Claims. (Cl. 74—573)

The present invention relates to an unbalance compensator for rotary parts.

It is known in certain applications that the center of gravity of rotary parts can shift during operation. Such shifting may take place gradually as, for example, on grinding wheels which wear down irregularly or which contain irregularly distributed moisture or the shifting may take place suddenly as in the case of the breaking a blade in a turbine or compressor.

Various devices for rapidly restoring balance are now known. The devices which have proved to be the most effective are those wherein several identical compensating masses are free to move within an annular fluid filled channel rigidly connected to the rotary shaft, each mass being restricted to a 120° movement. The spaces between the masses define chambers of variable volume and are each connected to a pressure intake which is sensitive to variations in pressure occurring between the shaft and a stationary reference member. The pressures transmitted to the chambers act on the compensating masses so as to displace them with respect to each other until the unbalance is corrected. The masses movable in the annular channel define a receiving sys- and the pressure transmitting means which produces a pilot signal under centrifugal force to cause the displacement of the masses defines a generator system.

The present invention relates to a new receiving system for unbalance compensators which may be controlled by or is responsive to any generator system.

In the type of compensator described, the receiving system was so arranged that each compensating mass played an identical role in that all the masses (generally 3) were free to move under the effect of the pressure differences prevailing on their opposite faces. In such systems all the masses (for instance balls) could move individually in chambers having the shape of a toroidal are spaced at equal angles and communicating with each other, or the stroke of the movable masses was limited in the annular channel by stops spaced apart at an equal angle and in this case, each of the spaces receiving the pressure signals in the channel were defined by two adjacent masses.

This arrangement in which all the compensating masses are free would appear most satisfactory as it meets the desire for initial "symmetry" or "structural balance" of the apparatus. In fact, such arrangement has drawbacks as herein explained. The case selected is that of a 3-mass compensator, as this is the most general, although the drawbacks are the same for a higher number of movable masses. In the event that an imbalance is present, the three masses distribute themselves irregularly in the channel establishing angles $\alpha 1$, $\alpha 2$, $\alpha 3$ different from 120°, so that the resultant center of gravity falls opposite the imbalance which created the signal, which condition can be realized for an infinite number of positions of each of the masses. The masses thus occupy a fixed position with respect to each other but not with respect to the channel and the center of gravity is in a state of stable equilibrium, without each of the masses inwardly being in stable equilibrium. As a result, if the rotating apparatus (for example a grinding wheel) is accelerated

or decelerated, the entire unit consisting of the three masses moves as a single member by inertia with respect to the channel so that the center of gravity of the three masses shifts and causes a new imbalance to appear (created by the balancing apparatus itself). Of course, this imbalance is automatically corrected in time, depending on the speed of response of the apparatus, this period being possibly as long as that which was necessary for the initial balancing, since the position of the masses in the new state of equilibrium may be different from that reached in the initial balancing, but is reproduced in a relatively sensitive manner upon each variation in speed of the machine (for instance each time that the tool comes into contact with the part to be machined).

Furthermore, there is an infinite number of relative positions of the three masses which give a center of gravity located at a given point and therefore upon the appearance of imbalance, the masses must seek their position among an infinite number of possibilities which tends to slow down their positioning or results in the risk that they will pass from one position to another.

When the machine has operated with the three masses distributed at angles $\alpha 1$, $\alpha 2$, $\alpha 3$ in order to balance an imbalance, if the machine is stopped temporarily the three masses first of all pivot as a single unit (particularly if the channel is filled with oil, as is most frequently the case), their center of gravity coming to the low point. If, at this time, the apparatus is again placed in operation, the apparatus must first of all rebalance the imbalance which it has caused to appear. In the event that the shutdown is for a longer period of time, each mass comes individually to the lowest point of its stroke as a result of the slight leaks of fluid between masses and annular channel. In this case also, the balancing must be re-established upon the replacing of the machine in operation, with the result that for a few moments compensation is not assured.

Finally, one of the features desired in imbalance compensators is speed of response and the various signal generator systems proposed have above all the purpose of supplying to the receiving apparatus the most effective signal possible, that is to say under the highest possible pressures and with the highest possible yields.

The effectiveness of these signals is greatly reduced in the receiving systems proposed up to the present time, due to the merely relative fluid-tightness of the spaces defined by the moving masses, since sufficient clearance must be left between these moving masses and the annular channel.

It is an object of the present invention to overcome the drawbacks which are inherent in devices in which all the masses are movable.

It is a further object of the invention to increase the speed of response to unbalance over the prior art compensators.

It is a further object of the invention to increase the sensitivity to small variations in balance.

The invention contemplates using as unbalance compensating means wherein one mass is fixed with respect to the rotary element, and two masses are movable within an annular fluid filled channel connected to the rotary element.

The invention will be understood from the detailed description read in view of the accompanying drawings, which show by way of illustration the preferred embodiments of the invention.

In the drawings:

FIG. 1 is a radial cross-section of an embodiment of a balancing device embodying the invention herein, the section being taken along line I—I of FIG. 2;

FIG. 2 shows the same device in section along the line II—II of FIG. 1;

FIG. 3 is a schematic showing in radial section along line III—III of FIG. 2 of a pressure signal generating system to feed fluid to the compensator; and

FIG. 4 is a view similar to FIG. 1, of a separate embodiment of the invention.

Referring to the drawings a member 2 of enlarged diameter is rigidly connected to the shaft 4, member 2 being provided with a recessed annular channel 6 concentric with the axis of the shaft 4. A cover 10 is fastened to the end member 2 away from shaft 4, and constitutes an end closure for the channel 6. The cross section of the channel 6 may be polygonal as shown, or round so that the channel forms a hollow torus. The channel 6 is divided by a fluid tight member 12 of limited arc, the member 12 constituting a stationary compensating mass. Positioned in channel 6 are two compensating masses or balance weights 14, 16 each having the same weight as the member 12. The movements of weights 14, 16 are limited by the member 12 and a diametrically opposite stop 18. As indicated the masses are spheres having a clearance about $\frac{2}{100}$ of a millimeter from the channel walls. A stop 18 is fixed to the member 2 diametrically opposite the partition 12 and serves to limit the movement of each of the masses 14, 16.

The masses 12, 14, 16 thus define three spaces 20, 22, 24 of variable volume, and lines or passages 26, 28, 30 open into the spaces at points which are not 120° apart and so disposed that one of the masses is always between two passages. As shown, lines 26 and 30 enter on opposite sides of the partition and line 28 enters diametrically opposite the partition. This disposition of the lines makes certain that the spaces 20, 22, 24 always receive a pressure signal, that is, the masses cannot be positioned to prevent pressure fluid from entering the assigned spaces. Lines 26, 28, 30 are connected by conduits 32, 34, 36 to pressure inlets 38, 40, 42 arranged 120° apart.

The pressure generating system comprises a stationary jacket 44 surrounding shaft 4. A fluid, such as oil or air, under pressure is fed into the space between the jacket and shaft through a line 46. Bearing 48 supports the shaft for rotation.

When an unbalance occurs—represented in FIGS. 1 and 2 by a mass 50—the shaft will rotate eccentrically. FIG. 3 is an exaggerated illustration of the eccentric position assumed by the shaft with respect to the jacket. The pressure in the fluid ring contained between the jacket and shaft is greater in the zone located on the side of the unbalance so that the pressures applied to intakes 38 and 42 are greater than the pressure applied to intake 40. These pressures are transmitted to zones 20, 22, 24. The pressures in zones 20 and 24 are greater than the pressure in zone 22 and therefore cause masses 14 and 16 to move away from the partition until the center of gravity of the three masses assumes a position in which unbalance 50 is compensated. Shifting of the center of gravity causes shaft 4 to return to a position of rotation concentric to jacket 44. The intakes 38, 40, 42 receive identical pressures which are transmitted to zones 20, 22, 24 and masses remain in the position of equilibrium.

It is thus seen that there is, for each imbalance to be compensated, one and only one position of the two moving masses, and said movable masses once they have been brought to their compensation position by the pilot pressures, occupy fixed positions with respect to each other as well as with respect to the turning unit, said positions being of stable equilibrium, which remedies the deficiencies heretofore existent in earlier systems.

It is therefore seen that the pressure variations which appear in zones 20 and 24 act positively on masses 14 and 16 as would occur in the case of pistons moving in a cylinder, the end of which is formed by the partition 12. Because of this a faster response to the pressure variations and increased sensitivity to small variations is obtained than heretofore was possible.

It can also be seen that in case of acceleration of the rotating unit, the masses 14 and 16 cannot be driven to turn as a unit with respect to the part 2 under the effect of their inertia, particularly if liquid fluid is used, as the fluid constitutes a cushion between the moving masses and the partition, and thus avoids parasitical imbalance due to the intertia.

Experimentation and calculation have shown that if the fixed mass 12 has the same weight as the movable masses 14 and 16, it is possible to precisely compensate for the same imbalance as with devices in which all the masses are movable and, for certain zones, it is possible to compensate for a higher imbalance due to the freedom of movement of the masses 12 and 14 which are 180° apart, instead of the maximum of 120° in the apparatus proposed heretofore.

In the illustrated embodiment the partition 12 is equal in weight to each of the masses 14, 16. However, a thin light partition 12*a* as seen in FIG. 4 may be substituted for the partition 12 and a fixed compensating mass 50 may be fixed at a suitable point on the part 2. In order that the result be the same as in the embodiment described above, it is necessary and sufficient that the compensating mass have its center of gravity on the radial plane of symmetry of the partition and that the product of its mass by the distance to the center of its center of gravity be equal to the corresponding product for a moving mass.

The invention is not limited to the embodiment described and shown but is capable of numerous variations, which will now be apparent to one skilled in the art, in view of the disclosure herein.

The invention having been explained, the following is claimed.

What is claimed is:

1. An unbalance compensator for a rotatable member comprising a body member, a chamber in said body member concentric with the axis of rotation of the rotatable member, a fixed partition in said chamber in fluid-tight relation with the walls thereof, a fixed stop in the chamber diametrically opposite the partition, a movable mass in said chamber between said stop and each side of the partition, said partition and each movable mass having the same weight, means for developing fluid pressure differentials about the axis of rotation of said rotatable member proportional to any unbalance therein, and conduits opening into said chamber at points between the partition and each movable mass and between each mass for transmitting said fluid pressure differentials to opposite sides of said partition and to opposite sides of each movable mass.

2. An unbalance compensator for a rotatable member comprising a body member, said body member having an annular chamber therein, concentric with the axis of rotation of the rotatable member, a fixed weight constituting a partition in said chamber, a stop in said chamber diametrically opposite the partition, a movable weight in each chamber space between the partition and the stop, and fluid means responsive to any unbalance in the rotatable member for moving each movable weight relative to the fixed weight and to each other in a direction and to an extent necessary to compensate for said unbalance, each of the movable and fixed weights being of equal weight.

3. An unbalance compensator for a rotatable shaft comprising a cylindrical body member mounted on the shaft and of greater diameter than the shaft, said body member having an annular chamber therein concentric with said shaft, a fixed weight constituting a fluid-tight partition in said chamber, a stop in said chamber diametrically opposite the weight, dividing said chamber in two portions, a pair of movable weights in said chamber, one in each portion thereof, each of the movable and fixed weights being of equal weight, three fluid passages leading from said chamber to the periphery of the shaft, one passage being adjacent one side of the partition,

one passage being adjacent the other side of the partition and one being opposite the stop, and means for developing fluid pressure differentials about said shaft proportional to any unbalance therein, said means including a sleeve member surrounding said periphery of the shaft with a clearance space therebetween, and a conduit for supplying fluid under pressure to the interior of said sleeve member.

4. Apparatus for automatically balancing a body mounted for rotation about its axis comprising a balancer member containing an annular chamber concentric with said axis, a fixed mass tightly inserted in said chamber, a stop means in said chamber positioned diametrically opposite said fixed mass, two movable masses in said chamber one of which is displaceable between one side of said fixed mass and one side of said stop means and the other of which is displaceable between the other side of said fixed mass and the other side of said stop means, said fixed mass and said two movable masses having substantially the same weight to constitute three balancing elements dividing said annular chamber into three arcuate chambers of variable volume, means for developing fluid pressure differentials about the axis of rotation of said body proportional to any unbalance therein, and means for transmitting said pressure differentials to said arcuate chambers so as to apply the pressure differentials at opposite sides of said balancing elements to effect displacement of said two movable masses relative to said fixed mass in a direction and to an extent necessary to compensate for said unbalance.

5. Apparatus according to claim 4, in which said fixed mass is constituted by a wall member extending radially through said annular chamber.

6. Apparatus for automatically balancing a body mounted for rotation about its axis comprising a balancer member containing an annular chamber concentric with said axis, a fixed mass tightly inserted in said chamber, a stop means in said chamber positioned diametrically opposite said fixed mass, two movable masses in said chamber one of which is displaceable between one side of said fixed mass and one side of said stop means and the other of which is displaceable between the other side of said fixed mass and the other side of said stop means, said fixed mass and said two movable masses dividing said annular chamber into three arcuate chambers of variable volume, said fixed mass comprising a wall member extending radially through said annular chamber the weight of which is smaller than that of each

movable mass, and a complementary part positioned on said balancer member in the same radial plane than said wall member, the weight of said complementary part being such as to compensate for the difference in weight between said wall member and each of said movable masses, means for developing fluid pressure differentials about the axis of rotation of said body proportional to any unbalance therein, and means for transmitting said pressure differentials to said arcuate chambers so as to apply the pressure differentials at opposite sides of said balancing elements to effect displacement of said two movable masses relative to said fixed mass in a direction and to an extent necessary to compensate for said unbalance.

7. An unbalance compensator for a rotatable member comprising a body member, a chamber in said body member concentric with the axis of rotation of the rotatable member, a fixed thin and light partition in said chamber in fluid-tight relation with the walls thereof, a fixed stop in the chamber diametrically opposite the partition, a movable mass in said chamber between said stop and each side of the partition, a weight fixed to the body member along the radial plane of symmetry of the partition, the product of its mass by the distance to the axis of rotation being equal to the product of the mass of a movable mass by the distance to the axis of rotation, means for developing fluid pressure differentials about the axis of rotation of said rotatable member proportional to any unbalance therein, and conduits opening into said chamber at points between the partition and each movable mass and between each mass for transmitting said fluid pressure differentials to opposite sides of said partition and to opposite sides of each movable mass.

8. A device as in claim 7 in which the conduits supplying the zones between the partition and each weight terminate adjacent the partition so that the terminals cannot be restricted by a weight in contact with the partition, and the conduit supplying the zone between each weight terminating opposite the stop so that the terminal cannot be restricted by either weight in contact with the stop.

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