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2,316,288

DEVICE FOR PREVENTING SPEED OSCILLATIONS AND VIBRATIONS
OF THE ROTARY MEMBERS OF MACHINES
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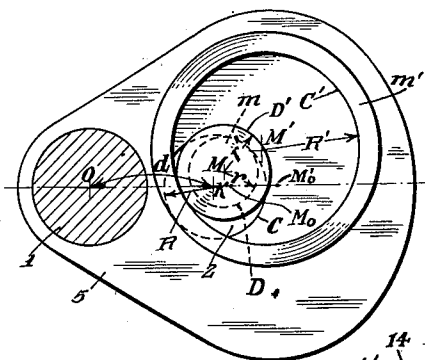


FIG. 1.

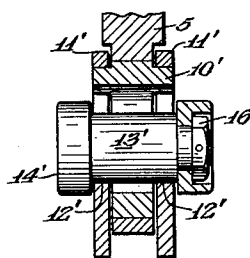


FIG. 3.

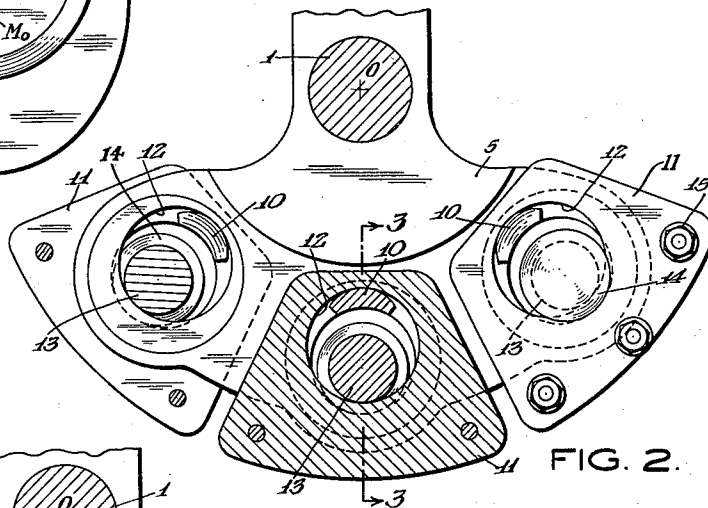


FIG. 2.

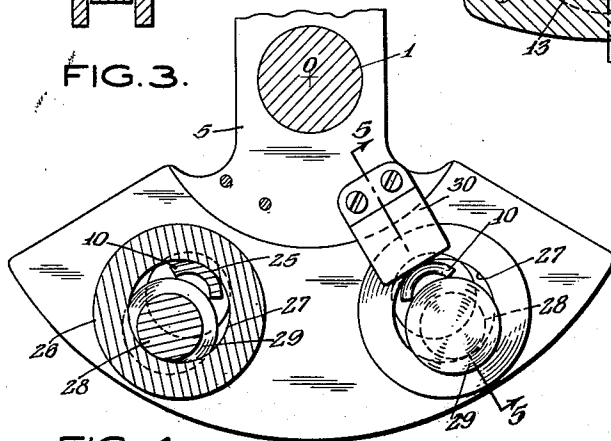


FIG. 4.

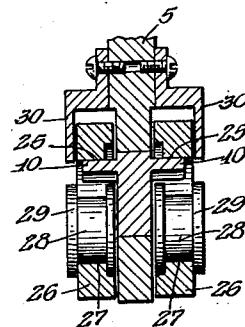


FIG. 5.

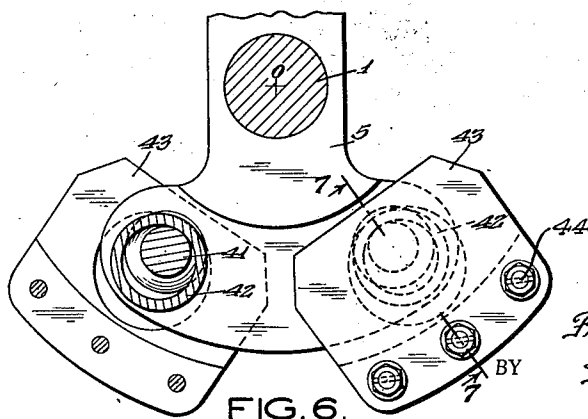


FIG. 6.

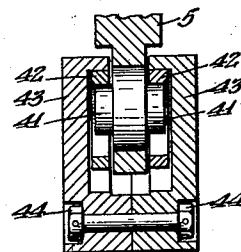


FIG. 7.

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DEVICE FOR PREVENTING SPEED OSCILLATIONS AND VIBRATIONS OF THE ROTARY MEMBERS OF MACHINES

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Application January 14, 1939, Serial No. 250,910
In Luxemburg January 8, 1938

5 Claims. (Cl. 74—604)

For regularizing the speed of the rotary members of machines and for preventing the torsional oscillations of rotating shafts, in particular of the shafts of engines, it has already been proposed to mount, on a body rigidly secured to the shaft or other rotating part, movable auxiliary masses which are subjected to the action of centrifugal force and are adapted to oscillate under the action of the disturbing forces and under the retracting action of the centrifugal forces, the oscillations of said auxiliary masses more or less completely compensating the oscillations that it is desired to prevent.

In particular, in French Patent 632,017, an oscillation reducing device has been described which is formed by auxiliary masses, each of which is so mounted that two of its points are compelled, during its oscillation, to describe two identical parallel curves relatively to the rotary machine member in question; by means of these kinematic connections, each auxiliary mass is made to effect an oscillating translatory movement about its normal position of equilibrium, without undergoing any rotation itself.

This method of mounting, which is sometimes called "bifilar suspension," may be efficient in certain cases, but it offers considerable drawbacks as regards complication and risks of wear.

In U. S. Patents Nos. 2,103,043 and 2,039,796, in particular, there are described very simple and very efficient unifilar devices.

It may be advantageous to construct, without the drawbacks of the bifilar suspension, unifilar devices in which certain of the oscillating masses move without rotation in the relative movement.

The absence of this rotation may, in certain cases, offer important advantages: it enables, in particular, without risk of sliding, the oscillating masses to undergo oscillatory angular movements of great amplitude, even if said masses possess a great inertia relatively to their centre of gravity.

The considerable advantages of the bifilar suspensions are thus retained, in many respects, and in particular as regards simplicity, and for certain of the oscillating masses, the advantage of the oscillating translatory movements is added.

Now, it has been found that this result may be obtained in an extremely simple manner according to the invention, the device being formed by one or a plurality of groups of at least two centrifugal auxiliary masses, the first of which is freely connected to the member of the machine and the other or each of the others to the previous one. The device is characterized by the fact that the geometrical and dynamic characteristics

of the system without a bifilar suspension are such that at least one of the auxiliary masses, other than the first, oscillates by translation without substantial rotation relatively to the machine member in question.

The same result is thus obtained, by purely dynamic methods, with unifilar suspensions, as is obtained with the known double kinematic connections.

In U. S. Patent No. 2,103,643, there are described similar devices which are formed in particular by a plurality or series of auxiliary masses that roll freely relatively to each other.

The present invention essentially consists in adapting the dimensions of said devices so as to obtain, by purely dynamic means, a suspension of the masses which is equivalent to the bifilar suspension. The device according to the invention may moreover be given all the practical embodiments described in the aforesaid U. S. patents, and also numerous other embodiments, some of which will be described hereinafter. In particular, each auxiliary mass which is adapted for oscillatory translation may be connected to the rotary machine member not only by one oscillating mass, but by a plurality arranged in series.

The invention will be described in detail with reference to the accompanying drawing in which:

Fig. 1 is a diagram illustrating the principle of the invention;

Fig. 2 is an elevation view, partly in section and with parts broken away and parts removed, showing one practical embodiment of the invention as applied to the counterbalance-weight of an engine crankshaft;

Fig. 3 is a sectional view taken substantially on line 3—3 of Fig. 2 by showing a slightly modified form of the invention;

Fig. 4 is an elevation view, partly in section and with parts broken away, showing another practical embodiment of the invention;

Fig. 5 is a sectional view taken substantially on line 5—5 of Fig. 4;

Fig. 6 is a side elevation view, partly in section and with parts removed, of still another embodiment of the invention; and

Fig. 7 is a sectional view taken substantially on line 7—7 of Fig. 6.

In Fig. 1, the machine member which is shown diagrammatically at 5, is rigidly secured to a shaft 1 for rotation therewith, said shaft having its axis at O. It is the object of the invention to substantially reduce or prevent the speed and/or torsional oscillations of said shaft.

The part 5 is provided with a cylindrical roller

way or bearing surface C having a radius R and an axis K which is spaced a distance d from the axis O. A mass m having its axis at M is provided with two cylindrical roller or bearing surfaces: by means of one, D, having a radius r, it rolls on the surface C and by means of the other, D', having a radius r' it conjugates itself with the cylindrical roller or bearing surface C' of a mass m', said last-named surface having a radius R' and an axis M'.

The masses m and m' are connected to each other and to the part 5 only by the free rolling contact produced by centrifugal force. When there is no oscillation of the shaft 1, the axes M and M' occupy the positions Mo, M'o, in the plane determined by the axes O and K, the axes O, K, M and M' being constantly parallel and perpendicular to the plane of the figure.

In Fig. 1, the masses m and m' have been assumed both to be formed by bodies of revolution, but this is in no way indispensable.

In the case in which the mass m is negligible relatively to the mass m', as is often the case in practice, it has been found that according to the invention, if the system satisfies the following conditions:

$$(1) \quad \frac{r}{r'} = \frac{R}{R'}$$

and

$$(2) \quad d = \left(\frac{\omega}{\Omega} \right)^2 \left(\frac{r}{r'} + 1 \right) (R' - r')$$

ω being the pulsation of the disturbing oscillations of the shaft 1 and Ω its mean angular speed, the condition for oscillating translatory movements is fulfilled for the mass m' and, simultaneously, one of the pulsations of the system itself in the field of the centrifugal forces is equal to the pulsation ω . These equations apply to the case in which the auxiliary masses oscillate in planes that are perpendicular to the axis of the rotary shaft.

In the other cases, the geometrical and dynamic elements of the system may either be determined by calculation, or by experiment, and may differ more or less from those which would ensue from said equations. In certain circumstances, the relative rotation of the mass m' might moreover not be absolutely nil.

Figs. 2 to 7 show, by way of non-limitative examples, different possible manners of mounting the auxiliary masses according to the invention.

In all the figures, which are more particularly but not exclusively applicable to radial aircraft engines, the reference numerals 1 and 0 correspond to the engine shaft and to its axis, respectively, and the reference numeral 5 to a counterbalance-weight arm on said shaft.

Fig. 2 shows a partial front and partial sectional elevational view of a device embodying three systems of damping masses and in which in each system, the first series of masses includes a mass 11 having internal bearing surfaces which rolls on external bearing surfaces of axially extending arm portions 10 which are carried by and fixed in relation to member 5. Each mass 11 comprises two cheeks, one on each side of member 5, assembled by means of bolts 15, one of the cheeks of the left-hand mass 11, as viewed in the drawing, being removed.

Each mass 11 has roller ways 12 for a mass 13 of the second series which carries lateral cheeks 14.

Fig. 3 shows a longitudinal section of a modification of Fig. 2, in which the reference numerals corresponding to those of Fig. 2 are supplemented

by the accent [']. In Fig. 3, the masses 11' are shown as being independent, but this is not indispensable. A nut 16 holds the parts assembled.

Fig. 4, and Fig. 5 which is approximately a longitudinal section of the device of Fig. 4, correspond to complex systems m, m' in which the masses 25 of the first series roll on internal tracks 26 which engage external bearing surfaces on arm portions 10. Masses 25 carry tracks 27 which are external with respect to the masses 25 which roll thereon and are provided with cheeks 28. Said masses are guided and retained by cheeks 30 secured to the member 5 which is driven by the rotary shaft 1.

Fig. 6, and Fig. 7 which is substantially a longitudinal section of the device of Fig. 6, relate to complex systems m, m' in which the two series of masses roll on roller ways that are inside same.

41 is a roller way which is secured to the rotary member 5 and is inside the masses of the first series 42.

The masses 43 of the second series are formed by cheeks which, by way of example, may be assembled by means of bolts 44, but could be independent of each other. One of the cheeks of the left-hand weight 43 is removed in Fig. 6.

In fact, Figs. 2 to 7 show, by way of example, a number of embodiments in which various combinations are effected of inner and outer roller ways, in pendulums having two stages of rolling oscillating masses.

In the various cases, abutments, not shown, limit the amplitudes of the oscillations.

It is possible, without exceeding the scope of the invention, to effect numerous modifications.

The number of masses of each stage, their shape, and the shape of the roller ways, etc. may vary very widely.

For example, as stated in the aforesaid prior patents, the roller ways may be of the most varied shapes, either cylindrical or of other shapes than the cylindrical shape.

In particular, it is possible in certain cases, to use balls for the masses of the first or of the second stage or of the following stages. In all these cases, the same general principles are applicable.

It is also quite obvious that the rotary member 5 may be absolutely of any kind: counterbalance-weight arm of an aircraft engine, flywheel of an engine or of a compressor, etc. It may be placed at any point of the rotary shaft, and, in the machine, said shaft itself may be the main shaft or any other shaft.

It has furthermore been found that it may be advantageous to deviate slightly, for example a few per cent, on one side or the other, from the condition given by Equation 2, and the system is given, relatively to the disturbing couple of the order in question, a fictitious inertia which is positive if d is made a little greater than according to Equation 2 and is negative if d is made a little smaller.

These properties play a fundamental part in reducing or damping the vibrations of shafts and also in questions of cyclic regularity.

I claim:

1. Apparatus for damping oscillations in a rotatable member having an arm rigid therewith and extending radially from the axis of rotation thereof, said apparatus comprising means rotatable with said member including an axially extending portion having an arcuate external bearing surface on both sides of said arm, said bearing surfaces being radially displaced from and curved

convexly toward said axis, damping means including masses freely suspended on said axially extending portions and having internal arcuate bearing surfaces engaging said first-named bearing surfaces, the radius of said internal bearing surfaces being greater than the radius of said first-named bearing surfaces, and a damping mass movably supported solely by said first-named masses and having arcuate bearing surfaces engaging arcuate bearing surfaces on said first-named masses, the radius of curvature of the last mentioned bearing surfaces of said first-named masses being greater than the radius of curvature of the cooperating bearing surfaces on said second-named mass and said second-named mass having free rolling movement along the cooperating bearing surfaces of said first-named masses.

2. Apparatus for damping oscillations in a rotatable member having an arm extending radially from the axis of rotation thereof, said apparatus comprising means rotatable with said member including an axially extending portion having an arcuate external bearing surface on both sides of said arm, the latter being radially displaced from and curved convexly toward the axis of rotation of said member, a first mass suspended on said axially extending portions and having internal arcuate bearing surfaces engaging said first-named bearing surfaces, the radius of said internal bearing surfaces being greater than the radius of said first-named bearing surfaces, and a second mass supported solely by said first mass and having arcuate external bearing surfaces engaging the internal bearing surfaces of said first mass on opposite sides of said arm and being free to roll thereon, the radius of the bearing surfaces of said first mass being greater than the radius of the bearing surfaces on said second mass and the latter having free rolling movement along the cooperating bearing surfaces of said first mass.

3. Apparatus for damping oscillations in a rotatable member having an arm extending radially from the axis of rotation thereof, said apparatus comprising means rotatable with said member including axially extending means having an external arcuate bearing surface on each side of said arm, the center of curvature of said surfaces being eccentric to the axis of rotation of said member, a first damping means including masses having internal arcuate bearing surfaces engaging said first-named bearing surfaces, the radius of the internal bearing surfaces being greater than the radius of said first-named bearing surfaces, and a second damping means constituted by a damping mass supported on said first damping means and having arcuate internal bearing surfaces engaging arcuate external bearing sur-

faces on said masses, the radius of curvature of the internal bearing surfaces of said second damping means being greater than the radius of curvature of the external bearing surfaces of said masses.

4. Apparatus for damping oscillations in a rotatable member having an arm rigid therewith and extending radially from the axis of rotation thereof, said apparatus comprising means rotatable with said member including opposed axially extending portions on opposite sides of said arm, said portions having arcuate external bearing surfaces which are radially displaced from and curved convexly toward said axis of rotation, a first damping means freely suspended on said axially extending portions and having internal arcuate bearing surfaces engaging said first-named bearing surfaces, the radius of said internal bearing surfaces being greater than the radius of said first-named bearing surfaces, and a second damping means constituted by a damping mass movably supported solely by said first damping means and having arcuate bearing surfaces engaging arcuate bearing surfaces on said first damping means at opposite sides of said arm, the radius of curvature of the bearing surfaces of one of said damping means being greater than the radius of curvature of the cooperating bearing surfaces on the other of said damping means and said second damping means having free rolling movement along the cooperating bearing surfaces of said first damping means.

5. Apparatus for damping oscillations in a rotatable member having an arm rigid therewith and extending radially from the axis of rotation thereof, said apparatus comprising means rotatable with said member including an axially extending portion having an arcuate external bearing surface on both sides of said arm, said bearing surfaces being radially displaced from and curved convexly toward said axis, damping means including masses freely suspended on said axially extending portions and having internal arcuate bearing surfaces engaging said first-named bearing surfaces, the radius of said internal bearing surfaces being greater than the radius of said first-named bearing surfaces, and a damping mass movably supported solely by said first-named masses and having arcuate bearing surfaces engaging arcuate bearing surfaces on said first-named masses, the radius of curvature of the bearing surfaces of said second-named mass being greater than the radius of curvature of the cooperating bearing surfaces on said first-named masses and said second-named mass having free rolling movement along the cooperating bearing surfaces of said first-named masses.

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