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GOVERNOR

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This invention relates to improvements in centrifugal governors, and more particularly to such improvements as will render the governors more stable and dependable and yet more sensitive in their governing action.

Centrifugal governors comprise flyweights which are commonly biased inwardly and thrown out by centrifugal force against their biasing. The flyweights are usually directly mounted on flat or leaf springs which provide the biasing for the weights. These springs are placed in relation to the shaft of the governor so that the direction of their mode of motion of greatest flexibility—i. e., in the case of flat springs the first mode of motion in bending—will be radial of the shaft which carries the governor, thereby permitting the flyweights to move principally in translation in the direction of the centrifugal force acting thereon. Flat springs have, however, various modes of motion or vibration other than the first mode of motion in bending just mentioned; these modes of motion, which are detrimental to the operation of the governor, comprise torsional motion (i. e., motion of the spring about and perpendicular to its longitudinal axis) and the higher modes of motion in bending. Considerable flexibility of the springs in the direction of its first mode of motion in bending is necessary to permit a sensitive governing action; on the other hand, a high degree of stiffness against motion of the springs in torsion and at the higher modes of motion in bending is highly important in order that vibrations of the mechanism being governed may not excite undesirable modes of motion or resonances in the governor and cause heavy vibration and unstable governing action.

It is an object of my invention to provide improved means by which a governor may be rendered stable and dependable and yet highly sensitive in operation.

Another object is to provide a governor which is well nigh free of undesirable resonances.

Another object is to provide a governor which is insensitive to mechanical vibrations such as may be transmitted to it by the mechanism which it controls.

A further object of my invention is to provide a spring mounting for the flyweight of a governor, which has considerable flexibility in but one mode of motion and a high stiffness against all other modes of motion.

A feature of my invention is to provide a resilient mounting for a flyweight of a centrifugal governor, which comprises a plurality of over-

lying flat springs spaced from each other and clamped against flexure along a portion thereof at the point of their support and at their point of connection with the flyweight.

Further objects and features of my invention lay in the provision, in a centrifugal governor, of such improved construction and arrangement of parts as will fulfill the purposes abovementioned.

Other and allied objects and features of my invention will more fully appear from the following description and the appended claims.

In the description of my invention reference is had to the accompanying drawing, of which:

Figure 1 is a side elevational view of a governor applied to a motor (fractionally shown) and incorporating my invention;

Figure 2 is a vertical sectional view taken substantially along the line 2—2 of Figure 1;

Figure 3 is a partial vertical sectional view taken substantially along the line 3—3 of Figure 1;

Figure 4 is a horizontal sectional view taken substantially along the line 4—4 of Figure 2;

Figure 5 is an end view of the governor;

Figure 6 is a view in side elevation of an alternative form of a portion of the governor; and

Figure 7 is a vertical sectional view taken along the line 7—7 of Figure 6.

Reference being had to the figures there will be seen a friction type of centrifugal governor incorporating my invention. A friction type of governor controls the speed of a power source by providing a frictional load on the source which increases with an increased speed of the source, and vice versa, about a predetermined speed established by the setting of the governor; such a power source may typically be an electrical motor M having a drive shaft 2 on which the governor may be directly mounted, as shown. Although my invention is particularly applicable to, and is herein illustrated and described in connection with, a friction type of governor, it is to be understood that no unnecessary limitation of my invention to this type of governor is intended.

A friction type of centrifugal governor may be of the following general construction: On the shaft 2 there are provided two relatively movable members, a collar 3 secured to the shaft by a set screw 4, and a sleeve 5 slidable along the shaft and preferably counterbored along its central portion so as to bear on the shaft at its end portions as at 5'. Staked to the sleeve 5 is a disk 6 and interconnecting this disk and the

collar 3 are flat springs 7 hereinafter more fully described. Secured to the springs 7 centrally thereof are flyweights 8. These flyweights are thrown outwardly by centrifugal force as the shaft 2 is rotated. As the flyweights are so moved the springs 7 are flexed (i. e., bowed outwardly) to cause the sleeve 5 to move along the shaft towards the collar 3. On the disk 6 is an annular friction ring 9 which, as the sleeve 5 is moved by the flyweights, is urged against a stop 10, thereby providing a frictional load on the motor. This frictional load is dependent upon the pressure with which the ring 9 is urged against the stop 10. Inasmuch as an increase in the centrifugal force action on the flyweights 8 will be transmitted at least in part to the friction ring 9 to cause an increase in pressure between the friction ring and its stop, speed increases of the motor will be counteracted by load increases, and vice versa, so as to subject the motor to a speed stabilizing influence.

In order to control the speed at which the governor action begins, the stop 10 is mounted for adjustment longitudinally of the shaft 2. The mounting for the stop may comprise a short arm 11 pinned to one end of a shaft 12 which is journaled in an extension 13 on the frame of the motor, as shown in Figures 2 and 4. Secured to the other end of the shaft 12 by a set screw 14 is an arm 15 which extends transversely of the motor. Passing through the outer end portion of the arm 15 and threading into a boss 16 on the frame of the motor is an adjusting screw 17, and interposed between the boss 16 and arm 15 about the adjusting screw 17 is a compression spring 18. This spring serves to hold the arm 15 against the head of the adjusting screw and also to frictionally hold the adjusting screw from turning in the boss 16. However, as desired, the adjusting screw may be turned manually to move the stop 10 towards or away from the friction ring 9 so as to control the speed at which the governor action begins—i. e., the speed at which the friction ring 9 contacts the stop 10.

As heretofore noted, it is highly important that the flyweights 8 be restricted so that they may move substantially only in translation as in a direction radial of the shaft 2. When this condition is realized vibrations of the motor M—such as may be caused by dynamic unbalance of the motor or by the pulsating nature of the developed torque as in A. C. motors—are prevented from causing undesirable modes of vibration or resonances of the flyweights. In accordance with my invention I provide a resilient mounting for the flyweights respectively which is so constructed and arranged as to be flexible substantially only in one direction—the direction of its first mode of motion in bending—and to be exceedingly stiff against all modes of motion in other directions. This resilient mounting is in the form of a spring structure comprising a plurality, or a pair as in the present instance, of flat springs 7 aforementioned; these springs are placed in face-to-face relationship so as to overlie one another, spaced radially in relation to the shaft 2 and clamped in fixed spaced relationship along a substantial portion thereof at the place of their support and at the place where they are connected to the flyweights 8.

The springs 7 of each pair are preferably clamped at their end portions and mounted so that they will be parallel to each other and to

the shaft 2 when they are unflexed—i. e., when the governor is in static condition as shown in Figure 4. In the present instance there are four flyweights and respective pairs of springs which are disposed at right angle intervals about the shaft 2. The spring pairs are secured along their outer end portions to the collar 3 by screws 19, the collar 3 being provided with four equiangularly spaced flats 3' forming seats for the respective pairs of springs. The screws 19 pass through the springs and through spacers 20 between the springs and then thread into the collar, thereby clamping the outer end portions of the springs tightly together in fixed spaced relationship and holding these portions of the springs securely to the collar. The inner end portions of the spring pairs are also clamped together, against respective spacers 21, by means of rivets 22, and the spacers 21 are secured to the disk 6 by screws 23. Secured to the central portion of the spring pairs are the respective flyweights 8 and interposed between the springs along their central portions are respective spacers 24 forming a portion of the flyweights. The flyweights and respective spacers and spring pairs are held together by rivets 25 which clamp the central portions of the spring pairs tightly against the spacers and flyweights.

In the twin-spring mounting structures just described, the flyweights are permitted to move radially outwardly in translation by way of a first mode of motion in bending of the spring pairs; however, undesirable movements of the flyweights by way of higher modes of motion in bending and a torsional mode of motion are well nigh prevented. This is because higher modes of motion in bending occur by way of an angular motion of the flyweights about an axis which is perpendicular to and in the medial plane of the springs and a torsional mode of motion occurs by way of an angular motion of the flyweights about an axis which is parallel to the longitudinal axis of the springs and in their medial plane. The higher modes of motion in bending will thus involve a stretching and compressing of the springs longitudinally thereof while a torsional mode of motion will involve a sidewise bending of the springs. Because of the high degree of stiffness of the springs in direct tension and of the extremely high degree of stiffness of the springs against sidewise bending (as because of their considerable width) the spring pairs are rendered exceedingly stiff against these undesirable modes.

It is to be understood that a highly important feature of the twin-spring structure as above described resides in the use of a plurality of spaced overlying springs which are clamped together, in fixed spaced relationship, along a substantial portion thereof in the region of their connection to the flyweight. Although I preferably mount these springs in the manner of a clamped-clamped beam (i. e., a beam which is fixed against torsional motion at its ends) I am not necessarily restricted to such a mounting as I may also advantageously employ this important feature of my invention in spring structures which are mounted in the manner of a cantilever or "clamped-free" beam, or in the manner of a "free-free" beam (i. e., a beam which is unrestricted against torsional motion at its ends as, for example, a beam having pivotally supported ends).

Of the undesirable modes of motion the torsional is frequently highly troublesome. To

obtain the maximum ratio of torsional stiffness to bending stiffness of the first mode, so as to subdue torsional vibration of the weights while yet not rendering the spring pairs so stiff in their first mode of motion in bending as to impede greatly the action of the governor, I find it desirable to employ relatively wide springs which are spaced far apart and made as thin and long as possible; this spacing between the springs is made at least a substantial fractional distance of their width and of the dimension of the flyweights in the radial direction of the shaft 2—for example, of the order of one-half or more, of these dimensions, as shown. The spring configuration shown in Figures 1 through 5 represents a practical design wherein these factors have been taken into account while yet maintaining a highly compact form of governor.

Since undesirable modes of motion of the flyweights, as by way of torsional motions and higher modes of motion in bending of the spring structures, are principally angular in character, to keep these undesirable modes of motion at a minimum it is important that the centrifugal forces acting on the flyweights be free of moments which would tend to excite such modes. The moments on the flyweights will be at a minimum when the flyweights are symmetrically disposed in relation to the spring structures with the center of gravity of the flyweights in the medial plane of the spring structures. In the embodiment disclosed in Figures 1 through 5 the twin-spring structures are symmetrically disposed in relation to the angular width of the flyweights 8 and the condition of a coincidence of the center of gravity with the medial plane of the twin-spring structures is approximated by causing the twin-spring structures to pass through the inner portion of the flyweights (the spaces 24 being considered as part of the flyweights as heretofore noted.) In this arrangement the twin-spring structures are kept close to the shaft 2 so as to reduce the overall size of the governor and yet moments acting on the flyweights are kept at a low value. In certain cases it may, however, be desirable to reduce the moments on the flyweights to a minimum. A construction in which this has been done is shown in Figures 6 and 7; here a spring structure comprising a pair of flat springs, such as the springs 7 hereinbefore described, is passed symmetrically through and secured to a flyweight 26 which by way of example is shown as block-shaped, the flyweight 26 being slotted as at 27 to permit the springs to pass therethrough and the springs being clamped to the flyweight against blocks 28 by means of the rivets 29. In this construction it is seen that the center of gravity O of the flyweight 26 lies in the medial plane P of the spring structure supporting the flyweight.

The flyweights 8 are preferably made in the shape of sectors which form when the governor is in static condition—i. e. when the springs are unflexed—a cylindrical structure coaxially disposed in relation to the shaft 2. This form of structure presents the maximum weight per unit of circumferential space, thereby enabling the maximum governing actuating force to be obtained for a given size of governor. While this shape of flyweight may in practical construction require that portions of the weights extend laterally beyond the mounting springs such extensions of the weights are in the present instance prevented from causing torsional vibrations of the weights by reason of the weights being

mounted symmetrically in relation to the mounting springs with the center of gravity of the weights close to the springs.

As an expedient in obtaining a highly sensitive governing action in friction-type governors, it is found important that the coaction between the friction ring 9 and stop 10 be essentially of a non-resilient character, or if a resilient effect is here present, that the resilience or stiffness be high in relation to the stiffness of the governor as seen by the friction ring. When this condition is realized an increase in governor speed above that which causes mere contact between the friction ring 9 and stop 10 will cause the increment of centrifugal force accompanying such speed increase to be almost wholly transmitted, in a ratio determined by the governor configuration, as a corresponding pressure increment between the friction ring and stop—that is, only a small percentage of this force increment on the weight will be lost or taken up by the governor springs, the remaining portion being effective to control the frictional load on the motor. Such efficient transmission of the centrifugal force on the weights into frictional load enables the governor to control the speed of the motor within a very narrow speed range. To obtain a high resilience or stiffness between the friction ring 9 and stop 10 I preferably employ a friction ring made of brake lining and a stop made of hardened metal.

The governor construction hereinabove described represents a practical design wherein various features of my invention are incorporated. While this combination of features have admirably fulfilled the objects of my invention it will be understood that these features may be employed singly or in combination, as desired, in various types of centrifugal governors and that the particular embodiment of my invention as herein shown and described is subject to many changes and modifications without departure from the scope of my invention, which I undertake to express according to the following claims.

I claim:

1. A resilient mounting for a flyweight of a centrifugal governor which is carried by a rotatable shaft, comprising a pair of supporting members mounted on said shaft for relative rectilinear movement therealong, a plurality of leaf springs connected at their end portions to said supporting members and at their central portions to said flyweight and each disposed parallel to the axis of said shaft; and spacing means clamped between said springs at their central and end portions for holding the springs spaced apart at said portions, the distance of spacing between the springs being at least a major fraction of the width of the springs.

2. In a centrifugal governor: including a rotatable supporting shaft and a flyweight: a mounting for said flyweight comprising a plurality of leaf springs arranged parallel to each other and disposed normal to the radius of said shaft, means clamping said springs together in fixed spaced relationship at their respective end portions and connecting said end portions to said shaft for relative movement, and means clamping the central portion of said springs together in fixed spaced relationship and securing the same to said flyweight, the distance of spacing between said springs bearing such relationship to the dimensions of said flyweight as substantially to restrict the movement of the flyweight to a

translational motion in a direction radial of the shaft.

3. In a centrifugal governor: the combination of flyweights symmetrically disposed in relation to the shaft of the governor; a supporting means 5 for each of said flyweights comprising a group of overlying flat springs radially spaced in relation to said shaft, the end portions of the springs of each group being connected to said shaft for relative movement and the central portion of 10 each group of said springs passing through the respective flyweight; and means clamping the springs of each group together in fixed spaced relationship at their end and central portions, the distance of spacing between said springs 15 being at least approximately half the dimension of the flyweights along the radius of said shaft to effectively restrict the flyweights to a translational motion in a direction radial of the shaft.

4. In a centrifugal governor: the combination 20 of a plurality of similar sector-shaped flyweights forming when in unoperated position a cylindrical structure coaxially disposed in relation to the shaft of the governor; and resilient supporting means for said respective flyweights adapted 25

to permit movement of the flyweights in translation in a direction radial of said shaft while restricting the flyweights against other movements, comprising a pair of relatively movable members on said shaft, a pair of overlying flat springs for the flyweights respectively, the springs of said pairs being radially spaced and longitudinally disposed relative to said shaft and being connected at their ends to said members and at their central portions to their respective flyweights, the central portion of each spring pair passing through its respective flyweight; and means clamping the spring pairs together in fixed spaced relationship at the place of their connection to the flyweights.

5. In a centrifugal governor: the combination of a flyweight; and a resilient beam structure for supporting said flyweight comprising a group of leaf springs spaced from one another, a portion of said structure passing through said flyweight and being secured thereto in a relationship wherein said portion is symmetrically disposed with respect to the center of gravity of the flyweight.

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