Sept. 23, 1941. H. J. KIRSCHNER 2,256,715

CENTRIFUGAL GOVERNOR

Filed Aug. 12, 1939 2 Sheets-Sheet 1

Fig. 1

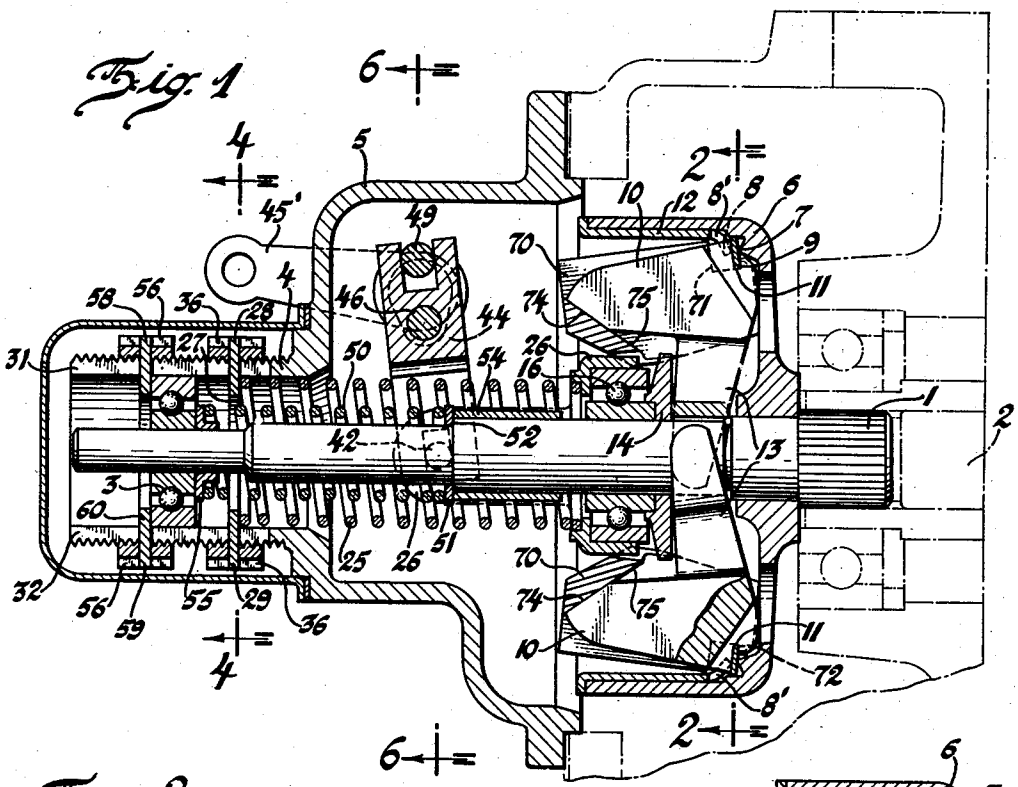
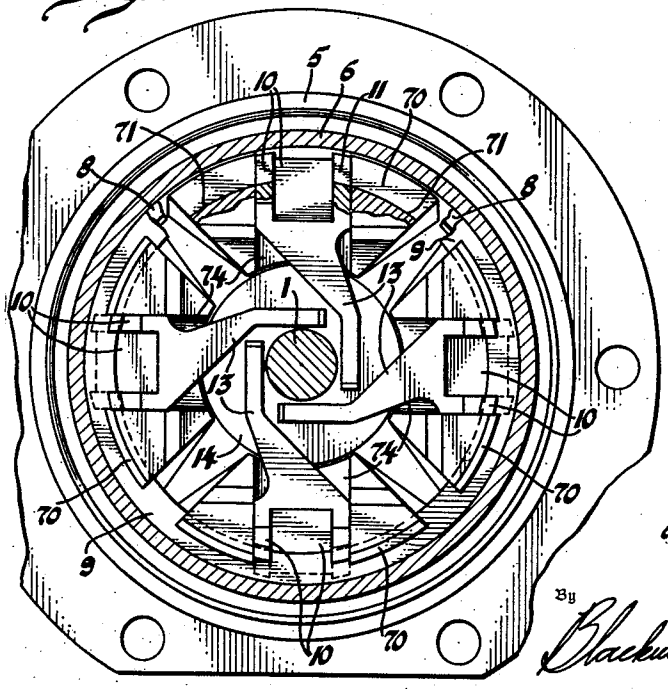


Fig. 2



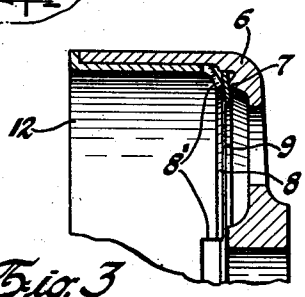


Fig. 3

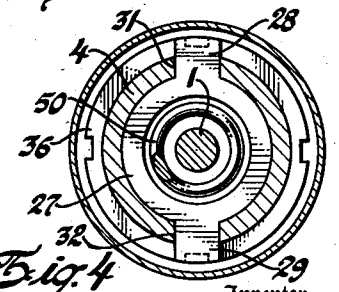


Fig. 4

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Sept. 23, 1941 H. J. KIRSCHNER 2,256,715

CENTRIFUGAL GOVERNOR

Filed Aug. 12, 1939 2 Sheets-Sheet 2

Fig. 5

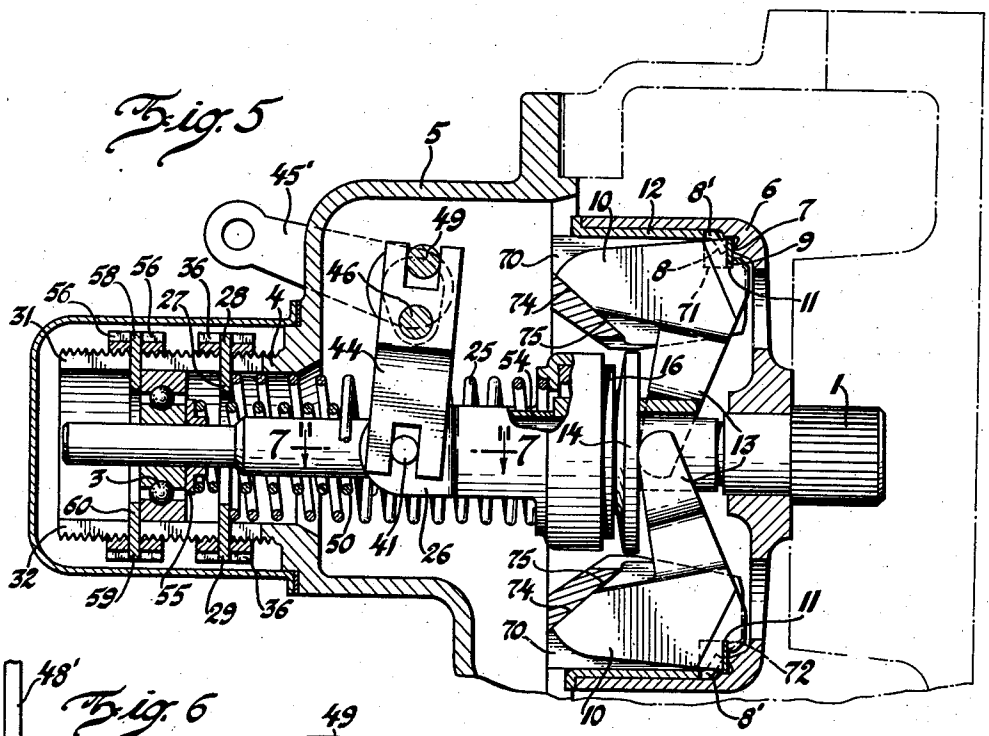
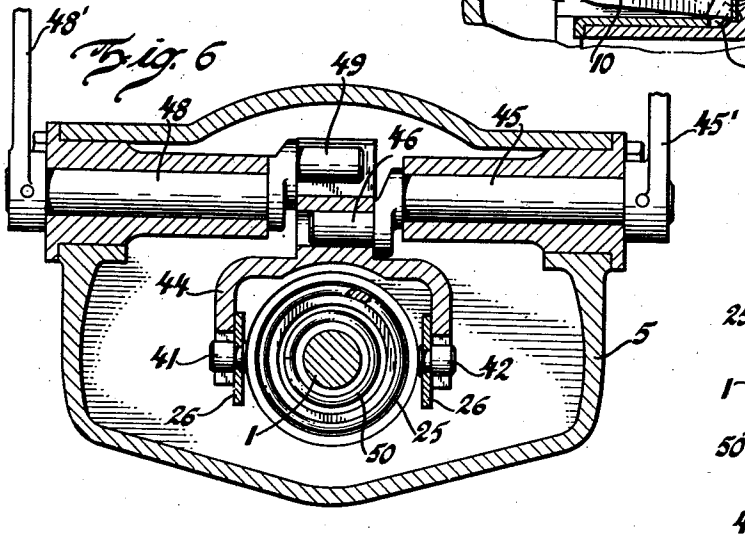


Fig. 6



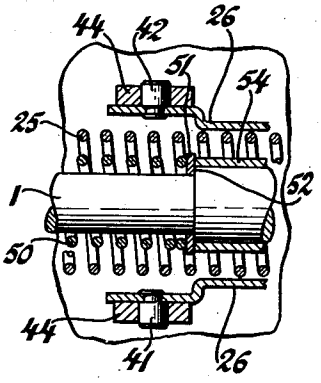


Fig. 7

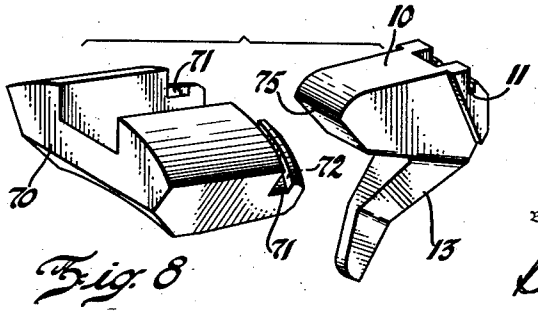


Fig. 8

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UNITED STATES PATENT OFFICE

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CENTRIFUGAL GOVERNOR

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Application August 12, 1939, Serial No. 289,927

9 Claims. (Cl. 264—18)

This invention relates to a centrifugal governor, and particularly to a governor for an internal combustion engine working under conditions of varying load and speed.

More especially it relates to a two stage governor having two sets of flyweights, and which is adapted to prevent the engine speed from dropping below a certain minimum and from exceeding a certain maximum. Both sets of flyweights are together operative to control the engine in its idling speed range, but only one set of flyweights is operative in its high speed range. In an intermediate speed range, none of the governor weights are operative to control the engine speed which is then controlled solely by manual means.

The object of the invention is a governor of small dimensions having considerable sensitivity with stability at both low and high speeds, especially suitable for controlling the fuel injectors of a Diesel engine.

Another object of the invention is a governor in which friction is reduced by mounting the centrifugally actuated flyweights on a Belleville washer (i. e. an annular disc spring) constituting a frictionless hinge therefor.

Another object of the invention is a governor in which the requisite spring force is supplied mainly by means common to all the weights and distinct from the Belleville washer on which the weights are mounted, which is however a comparatively thin and narrow flexible spring with a varying rate, which is positive opposing outward centrifugal movement of the weights at slow speeds of rotation, and negative, assisting outward centrifugal movement of the weights at high speeds of rotation.

A further object of the invention is a two stage governor of the foregoing type, in which two sets of weights are mounted on a single Belleville washer constituting a frictionless hinge therefor.

The above and other objects of the invention will be apparent as the description proceeds.

According to the invention, the governor flyweights are hingedly connected to a rotating governor shaft, through the medium of a Belleville washer on which they are mounted.

The Belleville washer has an annular fulcrum on a flanged disc secured to the shaft, and is deflected about this fulcrum by the flyweights which have a centrifugal moment thereabout, when the shaft is revolved. The centrifugal force is transmitted as an axial thrust, to a governor sleeve concentric with the shaft. Movement of the sleeve and hence of the flyweights, under the influence of centrifugal force, is resiliently opposed by suitable spring means. Axial movement of the sleeve, effects, through a suitable linkage, the required change in the quantity of fuel supplied to the engine.

The length of sleeve travel is a measure of the governor's sensitivity, and in order to make this as great as possible, while maintaining the overall dimensions of the governor as small as possible, the Belleville washer is comparatively thin, narrow and flexible, to permit a sufficient arc of movement of the flyweights.

Further according to the invention the governor is provided with two sets of flyweights, both sets being mounted on the same Belleville washer.

In the low or idling speed range, both sets of weights exert an axial thrust on the sleeve, and move it against the resistance of suitable spring means. When the upper limit of the idling speed range has been reached, one set of weights comes to rest against a stop. At this point no further movement of the lighter weights can occur until the resistance of an additional preloaded spring is overcome at the lower limit of the high speed range.

In the low speed range, the centrifugal moment of the comparatively large mass of both sets of weights is opposed only by comparatively light spring means. In the high speed range, the centrifugal moment of the comparatively small mass of only one set of weights is opposed by comparatively heavy spring means. By virtue of these conditions and because centrifugal force varies as the square of the speed, the governor may be more nearly equally sensitive in both speed ranges. Furthermore, while coil springs constitute the main spring means resisting outward centrifugal movement of the flyweights, the Belleville washer is itself a spring, so dimensioned and proportioned in the extent to which it is dished to the thickness of the material of which it is made that it may be buckled by deflection from a condition in which it exerts a force in one direction to a condition in which it exerts a force in an opposite direction. In the range of movement of the flyweights it is deflected from a condition in which (at low speeds) it is dished in one direction, to a condition in which (at high speeds) it is dished in an opposite direction. In the low speed range it has a spring rate which is positive opposing outward centrifugal movement of the flyweights, while in the high speed range it has a spring rate which is negative, assisting outward centrifugal movement of the flyweights. It therefore can be arranged to appre-

ciably increase the rate of the main spring means in the low speed range and to decrease it slightly in the high speed range, thus increasing the speed droop, (i. e. the ratio of governor speed change for a full change in engine torque, to the mean governor speed) in the low speed range and decreasing it slightly in the high speed range. This is desirable because for maximum stability, an appreciably higher speed droop is required in the low speed range.

The drawings show one example of a construction according to the invention.

In the drawings:

Fig. 1 is a sectional view, showing the position of the parts when the governor shaft is stationary.

Fig. 2 is a sectional, partly broken away view, on line 2—2 of Fig. 1.

Fig. 3 is a detail view of parts of Fig. 1.

Fig. 4 is a sectional view on line 4—4 of Fig. 1.

Fig. 5 is a sectional view similar to Fig. 1, but showing the position of the parts at the upper limit of the idling or slow speed range of the governor.

Fig. 6 is a sectional view on line 6—6 of Fig. 1.

Fig. 7 is a sectional view of a part on line 7—7 of Fig. 5.

Fig. 8 shows perspective views of one of each set of governor weights.

The rotating governor shaft 1 has a splined coupling to any suitable shaft such as 2, driven by the engine (of which only a part is shown in dot and dash lines in Figs. 1 and 2), at a fixed speed ratio. Its outer end is supported in a ball bearing 3, in an extension 4, of the governor housing 5.

Rigidly secured to the shaft 1, is a cup-shaped shell 6, having an annular fulcrum 7, for a Belleville washer 9.

A set of four flyweights such as 10, symmetrically disposed about the axes of the shaft 1, are mounted on the Belleville washer 9. They are provided with notches 11, the sides of which embrace opposite sides of the inner edge of the Belleville washer 9.

The Belleville washer 9 is held against its annular fulcrum 7, by a ring 12, which is pressed into position in the shell 6 and has an inturned edge 8 between which and the fulcrum 7, the Belleville washer 9 is retained. The inturned edge 8 of the ring 12 is cut away at four places 8' (as shown most clearly in Fig. 3). The uncut away portions of the edge 8 constitute circumferential spacers for the weights 10, through which they are driven, while at the same time the cut away portions permit the weights 10 to bear across substantially the whole width of the face of the Belleville washer on that side thereof remote from the fulcrum 7.

The flyweights 10 are bellcrank shaped, each being provided with an arm 13 extending tangentially of the shaft 1 and bearing on a disc 14, which is slidable on the shaft 1 and bears on the inner race of a ball bearing 16, also slidable on the shaft 1.

A coil spring 25 has a seating on a two-armed yoke piece 26 having a cupped portion embracing the outer race of the ball bearing 16. The coil spring 25 yieldingly urges the assembly including the yoke 26, the ball bearing 16, and the disc 14, into contact with the arms 13 of the flyweights 10, thereby opposing their outward centrifugal pivotal movement about the annular fulcrum 7.

The end of the coil spring 25 opposite from the yoke piece 26, has a seating constituted by an annular disc 27 encircling the shaft 1, and having diametrically opposite lugs 28 and 29, extending through, and slidable in diametrically opposite slots 31 and 32, in the externally threaded extension 4, of the housing 5.

Nuts 36 on the threaded extension 4 of the housing, serve as abutments for the lugs 28 and 29 of the annular disc 27, and the loading of the spring 25 may be varied by a screwing adjustment of the nuts 36.

Outward hinging movement of the weights 10 under the influence of centrifugal force is permitted by deflection of the Belleville washer 9 about its fulcrum 7. As the weights hinge outwardly, their arms 13 move the ball bearing 16 axially of the shaft 1, against the resistance of the return spring 25.

The parts thus far described are all that are necessary for a simple governor. It will be appreciated that the spring 25 does not revolve with the shaft 1 and that the yoke piece 26, with the outer race of the ball bearing 16, constitutes a sliding, non-rotating governor sleeve, whose axial movement is a measure of the engine speed, which may be used to control the amount of fuel supplied to the engine.

In the example illustrated, the yoke piece 26 has two diametrically opposite pins 41 and 42, which engage the bifurcated ends of a forked lever 44. The forked lever 44 constitutes a differential linkage between the yoke piece 26, a manual control means for the engine, and a member which varies the quantity of fuel supplied to the engine. The manual control means for the engine is a shaft 45 having a cranked end 46 on which the lever 44 is fulcrumed intermediate of its ends. The member which varies the quantity of fuel supplied to the engine is a shaft 48 coaxial with the shaft 45 and having a cranked end 49 engaging a slot in that end of the lever 44 opposite from its forked end connection to the yoke piece 26. The shafts 45 and 48 are turnable through a certain arc of rotation in the governor housing 5 and the arrangement is such that the turning of the shaft 48 and hence the varying of the quantity of fuel supplied to the engine is controlled differentially by the turning movement of the manual control means 45 and the axial movement of the yoke piece 26.

The shaft 45 is turned manually or otherwise as may be desired, through any suitable linkage (not shown) to the lever 45' secured on the shaft 45; turning of the shaft 48, in response to movement of the lever 45', or the yoke piece 26, or both differentially, and variation in the quantity of fuel supplied to the engine, is effected through any suitable linkage to the engine fuel supply means (not shown) from the lever 48' secured on the shaft 48.

The manner in which the foregoing governor is modified for two-stage operation will now be described.

In the annular space between the shaft 1 and the coil spring 25, is a coil spring 50, which revolves with the shaft 1 and seats on a washer 51 against a shoulder 52 on the shaft 1 at a point intermediate of the ends of the spring 25, when it is not against a tubular distance piece 54, slidable on the shaft 1 between the inner race of the ball bearing 16 and the washer 51. The other end of the coil spring 50 extends into the extension 4 of the housing, to a point beyond the end of the spring 25, where it has a seating 55 bearing against the slidable inner race of the ball

bearing 3 in which the outer end of the shaft 1 is supported. The outer race of the ball bearing 3 is slidable in the extension 4 of the housing.

Nuts 56 on the threaded extension 4 of the housing serve as abutments for the lugs 58 and 59 of an annular disc 60, which is an abutment for the stationary outer race of the ball bearing 3, through which the loading of the spring 50 against the shoulder 52, may be varied by a screwing adjustment of the nuts 56.

The length of the tubular distance piece 54 is such that, at low speeds of operation of the governor, the preloaded spring 50 exerts no thrust opposing outward centrifugal movement of the flyweights 10, and not until at higher speeds, the distance between the shoulder 52 and the inner race of the ball bearing 16 has been taken up by the distance piece which is then thrust against the washer 51, is the preloaded spring 50 operative to oppose its load against the outward centrifugal movement of the flyweights.

At low speeds, only the load of the spring 25 opposes outward movement of the weights 10. When a speed at which the distance piece 54 exerts a thrust on the washer 51 is reached, no further outward movement of the weights 10 and consequent axial movement of the governor yoke piece 26 can take place, until a higher speed, with a greater centrifugal force sufficient to overcome the preloading of the spring 50 in addition to the load of the spring 25 is reached.

In the intermediate speed range, in which the position of the yoke piece 26 remains fixed, the amount of fuel supplied to the engine is controlled solely by manual turning of the shaft 45, which moves the forked lever 44 about the now stationary fulcrum constituted by the pins 41 and 42, to turn the shaft 48 which varies the quantity of fuel supplied to the engine.

In order to improve the governor power and response in the idling speed range, a second set of four flyweights, operative only in the idling speed range, is mounted on the Belleville washer 9. It consists of flyweights such as 70 which are generally U-shaped, and each of which straddles one of the flyweights such as 10 by which they are circumferentially positioned and driven. They are provided with notches 71 which are wider than the thickness of the Belleville washer 9. They are held with the side 72 of the notches against the fulcrum side of the Belleville washer 9, by force components of the pressure of the coil spring 25 and centrifugal force at the coacting inclined surfaces 74 and 75 respectively, on the underside of the bridge portion of the weights 70 and at the tip of the weights 10.

Both sets of weights 10 and 70 pivot outwardly together, deflecting the Belleville washer 9 about its fulcrum 7, in the idling speed range of the governor. The centrifugal thrust of the weights 70, is transmitted to the surface 75 of the weights 10, and through the arms 13 thereof to the yoke piece 26, which is moved against the resistance of the spring 25.

When the upper limit of the idling speed range is reached, further outward movement of the weights 70 is stopped by the ring 12 with which they come in contact. This position of the weights 70 coincides with that position of the yoke piece 26 in which the tubular distance piece 54 is being thrust against the washer 51, and the yoke piece 26 begins to be subjected to an additional load from the spring 50, (as shown in Figs. 5 and 7).

At this point, no further movement of the weights 10 can occur until the speed increases to the point where the centrifugal force of the weights 10 is sufficient to overcome the combined resistance of the springs 25 and 50. The wide notch 71 in the weights 70 provides clearance which permits the further deflection of the Belleville washer 9 by the weights 10, independently of the weights 70 whose movement is stopped by the ring 12. The use of four weights in each set enables a close approach to maximum centrifugal moment, minimum weight travel, and maximum governor sleeve travel, in a governor of minimum dimensions; these together with other features of the invention are the requirements of a good governor.

I claim:

1. In a governor, in combination, a rotating shaft, a plurality of flyweights revolving therewith, a Belleville washer hingedly connecting the flyweights to the rotating shaft, and spring means resiliently resisting outward hinging movement of the flyweights under the influence of centrifugal force.

2. The combination according to claim 1, in which the flyweights are mounted on the inner periphery of the Belleville washer which has, intermediate of its inner and outer peripheries, an annular fulcrum secured to the rotating shaft, about which it is angularly flexed by the centrifugal force of the flywheels.

3. The combination according to claim 1, in which the Belleville washer is itself a spring with a varying rate, which is positive and opposes outward centrifugal movement of the flyweights at slow speeds of rotation, and negative, assisting outward centrifugal movement of the flyweights at high speeds of rotation.

4. In a governor in combination, a rotating shaft, a first and a second set of flyweights revolving therewith, a Belleville washer hingedly connecting the flyweights to the rotating shaft, said Belleville washer being angularly flexed by the centrifugal force of the flyweights about an annular fulcrum secured to the rotating shaft, coil spring means resiliently resisting outward hinging movement of the flyweights under the influence of centrifugal force, and stop means limiting the outward hinging movement of the second of said sets of flyweights, while permitting further outward hinging movement of the first of said sets of flyweights accompanied by further angular flexing of the Belleville washer, and compression of the coil spring means.

5. The combination according to claim 4, in which the flyweights are hooked on to the Belleville washer, the first of said sets of flyweights having notches the sides of which embrace opposite sides of the inner edge of the Belleville washer, and the second of said sets of flyweights having notches which are wider than the thickness of the Belleville washer and being held with one side of the notches against the fulcrum side of the Belleville washer; there being clearance between the Belleville washer and the other side of the notches in the second of said sets of flyweights to permit further angular flexing of the Belleville washer by the first of said sets of flyweights, after the second of said sets of flyweights has reached its stop means.

6. The combination according to claim 4, in which the spring means includes a coil spring resiliently resisting outward hinging movement of both sets of weights at slow speeds of rotation, and after one of said sets of flyweights has reached its stop means, a second preloaded coil spring is

operative to assist the first of said coil springs in resiliently resisting outward hinging movement of the other of said sets of flyweights at high speeds of rotation.

7. The combination according to claim 4, in which the spring means is operative on the flyweights of the first set through a yoke piece coaxial with the shaft, and thence on the flyweights of the second set through the flyweights of the first set; the position of said yoke piece axially of the shaft, being dependent on the spring pressure, as opposed by the centrifugal moment of the flyweights.

8. The combination according to claim 4, in which the flyweights of the first of said sets are hooked on to the Belleville washer and circumferentially spaced thereon by a retaining ring for the Belleville washer, said retaining ring having portions cut away to clear the respective flyweights of said set, and spacing portions therebetween.

9. The combination according to claim 4, in which the flyweights of the first of said sets are hooked on to the Belleville washer and circumferentially spaced thereon by a retaining ring for the Belleville washer, said retaining ring having portions cut away to clear the respective flyweights of said set, and spacing portions therebetween; the flyweights of the second of said sets also being hooked on to the Belleville washer, each straddling a corresponding flyweight of the first of said sets by which they are circumferentially spaced and held on the Belleville washer.

HENRY J. KIRSCHNER.