

Dec. 30, 1941.

A. C. HOOF

2,267,919

CENTRIFUGAL GOVERNOR

Filed Dec. 13, 1939

3 Sheets-Sheet 2

FIG. 2.

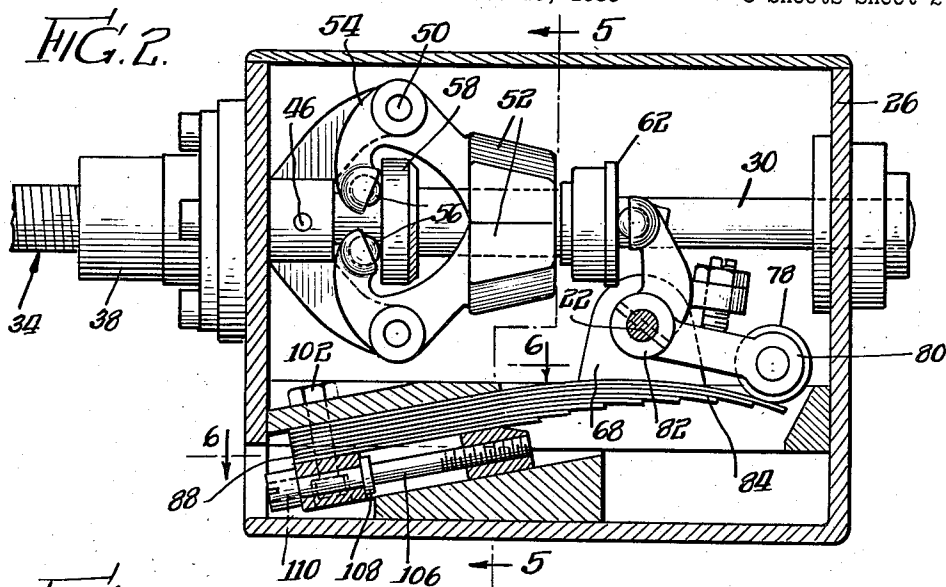


FIG. 3.

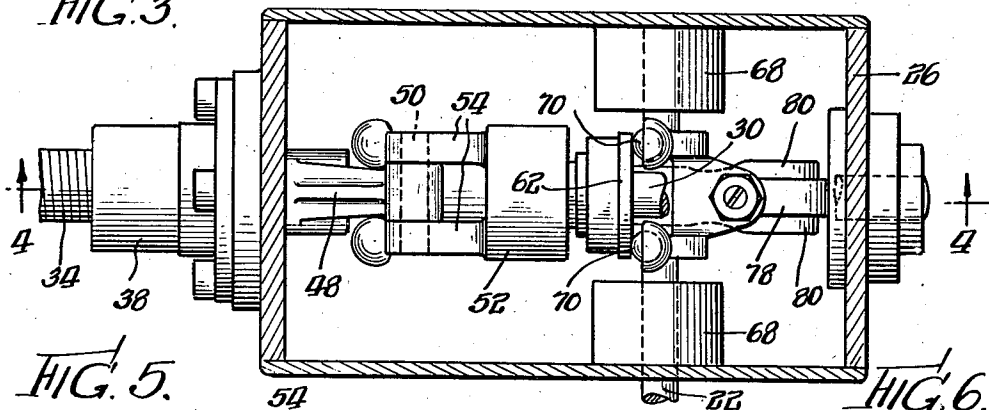


FIG. 5.

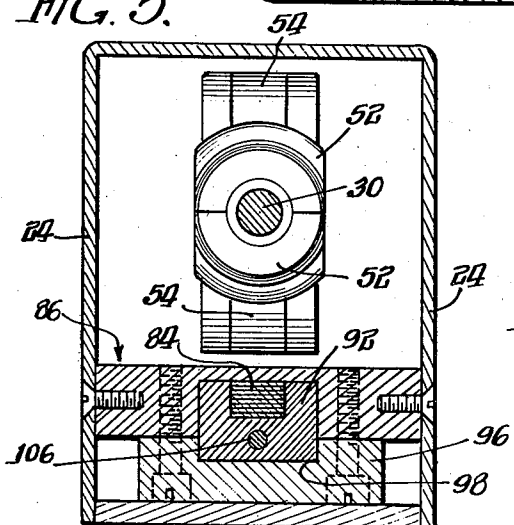
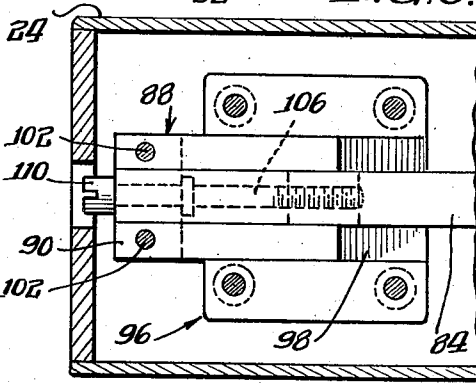


FIG. 6.



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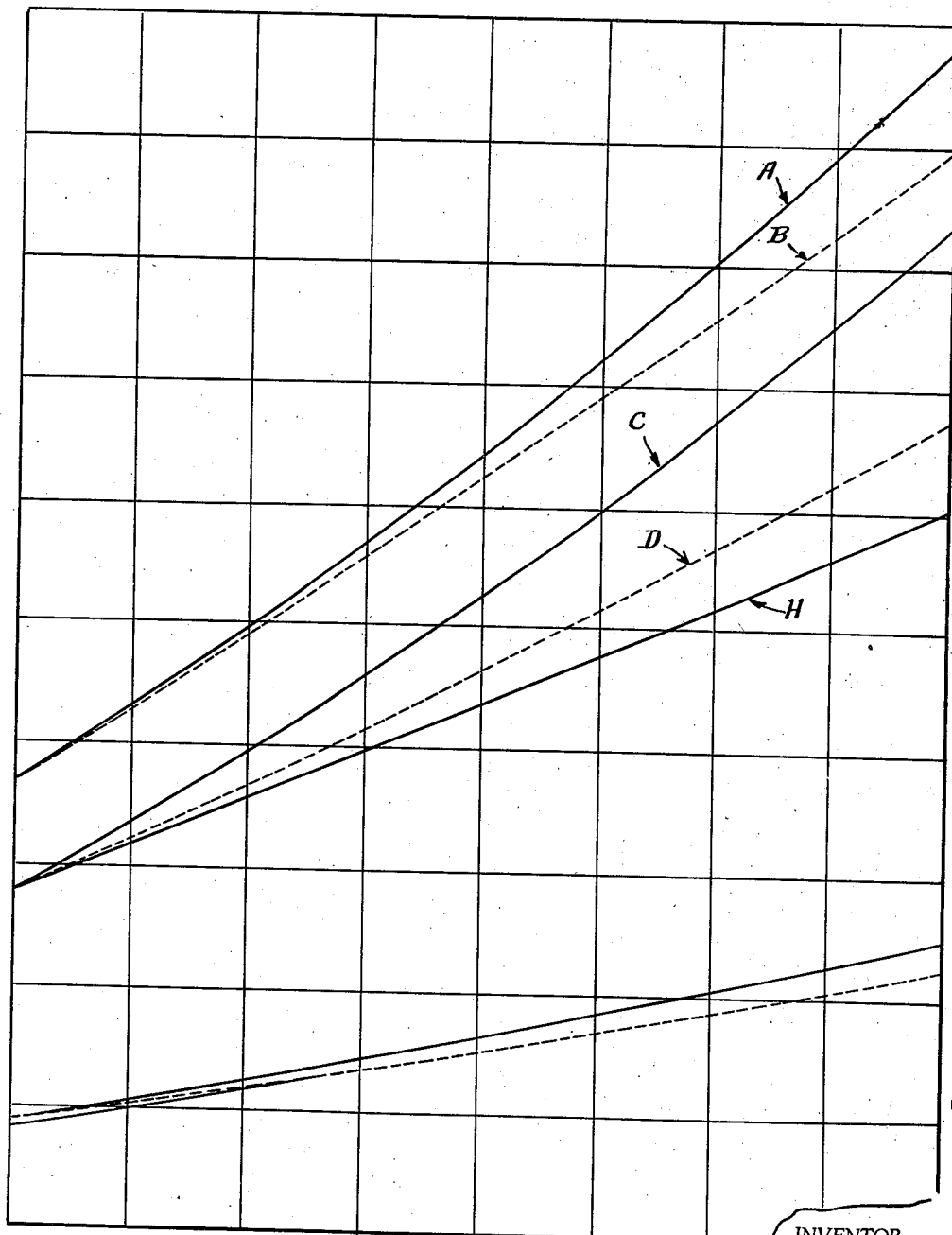
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3 Sheets-Sheet 3

FIG. 9.



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UNITED STATES PATENT OFFICE

2,267,919

CENTRIFUGAL GOVERNOR

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Application December 13, 1939, Serial No. 308,979

14 Claims: (Cl. 264—15)

The present invention relates to a governor device for controlling the speed of operation of an engine and more particularly relates to a governor of the centrifugal type for controlling the flow of a fluid fuel to the engine for maintaining a constant, predetermined speed of operation.

In general, devices of the instant class operate by imposing the resultants of a centrifugal force upon a yieldable, resisting means in such a manner that the resulting movement of the parts may be employed to correspondingly shift a fuel supply valve to maintain the engine speed constant, regardless of variation in load. The present invention more particularly contemplates a novel combination of centrifugal means and yielding means wherein the centrifugal resultants are imposed upon the spring in such a manner as to more nearly meet the fundamental requirements of a centrifugal governor. In other words, the alteration of spring characteristics with respect to the centrifugal force resultants, as theoretically understood, is a requirement not inherent in the prior fly ball governor spring arrangements with which I have been hitherto familiar.

It is, therefore, an important object of the present invention to provide an improved means for resisting the centrifugal force resultants in accordance with the practical and theoretical requirements for accurate control of engine speed.

The present invention more particularly contemplates the attainment of the foregoing objects by the use of a cantilever spring of the type described in United States Patent No. 1,324,198, granted December 9, 1919, to Krebs et al. This patent describes one important result of this type of spring, to-wit: the fact that its deflection rate varies, in general, according to the cube of its length making it desirable for use in variable speed governors. In other words, since the resultants of the centrifugal forces of the fly ball unit vary as the square of the speed of rotation, a corresponding wide range of variability of spring tension is necessary to render the governor operable to control speeds over any reasonable range. In accordance with the Krebs construction, it is merely necessary to alter the effective length of the spring to a moderate range to render the device adjustable for all practical speed ranges. Thus, for example, to provide a speed range of from 1,000 R. P. M. to 2,000 R. P. M., it is only necessary to alter the effective length of the spring from a ratio of approximately 1.58 to 1 where the centrifugal force re-

sultants are imposed upon the free extremity of the spring, as taught by the Krebs et al. patent.

It has been found, however, that limitations of space and considerations of friction as well as spring stresses and characteristics prevent the full realization of the theoretical advantages of the structure described in the patent. Thus difficulties have been experienced due to the practical limitations on the minimum size of the spring imposed by the flexure necessary to control the engine over a reasonable range of valve positions and further, in view of the undesirable changes in spring characteristics which occur as the result of variation in angle of application of the centrifugal force resultants as the spring flexes through an appreciable arc.

The foregoing and other difficulties are inherent in the type of structure wherein the spring deflecting forces are applied at all times to the end of the spring in a suitable link.

The present invention has for its object to obviate the foregoing disadvantages and, in particular, to make possible a wide range of adjustment in a compact unit by imposing the centrifugal force resultants on the spring in such a manner as to relatively rapidly increase the effective resistance of the spring as the parts move toward the position of maximum spring loading. In other words, the present invention contemplates the relatively sharp increase in value of the spring tension so as to render permissible the use of a shorter and lighter spring than was heretofore structurally necessary in practical use.

A further important object of the present invention contemplates the controlled imposition of the centrifugal force resultants on the spring in such a manner that the increase in spring resistance is somewhat disproportionate to the deflection and in particular comprehends the correlation of the said disproportionate increase in such a manner as to make possible conformance of spring loading and centrifugal force resultants with the minimum speed variation throughout the governing range of the load.

A yet further object of the present invention contemplates the provision of an auxiliary adjustment means cooperative with the adjustment means which determines the effective length of the spring, which auxiliary adjustment may be employed to vary the foregoing conformations of spring loading and centrifugal force resultants in such a manner as to control the sharpness of governor action and thus confer stability of operation.

Yet other and further objects and advantages will be apparent from a consideration of the foregoing detailed description when taken in connection with the accompanying drawings, wherein:

Fig. 1 is an elevational view more or less diagrammatically illustrating the operating disposition upon an engine of a governor embodying the principles of the present invention.

Fig. 2 is an elevational view of the governor shown in Fig. 1, portions of the side wall having been broken away to show the construction of the governor parts.

Fig. 3 is a plan view of the governor shown in Fig. 2 with the cover removed.

Fig. 4 is a view taken on the line 4—4 of Fig. 3, but showing the parts of the governor in one position taken when the governor is in control of the engine.

Fig. 5 is a detailed sectional view taken on line 5—5 of Fig. 2.

Fig. 6 is a detailed view taken on the line 6—6 of Fig. 2.

Fig. 7 is a view of the parts making up the adjustable bell crank lever and roller follower assembly, the parts being shown in perspective in spaced relationship to indicate their individual construction.

Fig. 8 is a perspective view of the spring mounting elements, the parts being similarly shown in spaced relationship to indicate their individual construction.

Fig. 9 is a chart showing the characteristics of the spring loading and centrifugal force resultants in the present governor.

The governor shown in the drawings, for the purpose of illustrating one embodiment of the present invention, is designated by numeral 10 in Fig. 1 and is operatively disposed adjacent the intake conduit 12 of an engine 14 for controlling the location of a fuel valve 16. It will be noted that the fuel valve 16 is located in the conduit between the intake manifold 18 and the carburetor 20.

As noted above, the present invention concerns particularly a novel means for imposing resultants of centrifugal forces on a resilient, yieldable spring for determining the position of the valve 16. The centrifugal and yielding structures are enclosed within the housing 10 and it will be understood that the valve 16 is connected in a suitable manner to control shaft 22 emanating from the housing 10.

The structure of the unit 10, shown more clearly in Figs. 2 to 6, includes an outer housing 24 having opposed end walls 26 and 28 journaling a longitudinally extending shaft 30 in anti-friction bearings 32. It will be noted that the left-hand end of the shaft 30, as viewed in Fig. 4, connects with a flexible drive shaft 34 through the agency of a coupling 36, the flexible drive shaft being enclosed within a suitable armor or protective sheathing 38 engaging at its extremity in bushing 40 permanently secured to the end wall 28 of the housing as at 42.

It is to be understood that the flexible drive shaft 34 is adapted to rotate the spindle 30 in correspondence to the speed of rotation of the crank shaft of the engine 14, to which end the flexible shaft 34 connects therewith. In the present embodiment it will be seen that the flexible shaft 34 is indirectly, though positively, driven from the engine shaft.

The shaft 30 interiorly of the housing mounts a so-called fly ball or centrifugal governor mechanism comprising a collar 44 pinned to the shaft

30 as at 46 and having integral, opposed, projecting arms 48 which support at their outer extremities a pair of pivot pins 50. A pair of so-called fly balls or weights 52 integral with bell crank arms 54 are rotatably mounted on the pivots 50. Bell cranks 54 are recessed at their inner extremities to receive anti-friction balls 56 bearing against a collar 58 on the end of sleeve 60 which is slidable axially of shaft 30. It will be quite obvious from the foregoing that as the weights 52 are moved outwardly under the influence of centrifugal force as the shaft 30 rotates, the opposite extremities of the bell crank levers 54 urge the collar 58 and its associated sleeve to the right along the shaft 30, as seen in Figs. 2 and 4.

The opposite extremity of the sleeve 60 mounts a thrust bearing 62 for application of the centrifugal force resultants against a lever 64. The lever 64 forms a part of an adjustable bell crank lever system, to be hereinafter more fully described, and pivoted upon a transverse shaft 22 journaled in opposed lugs or embossments 68 formed in either side of the housing 24. As shown more clearly in Fig. 7, a lever member 64 comprises two spaced sections having at their thrust bearing contacting extremities spherical inserts 70 and spaced by a transverse connecting lug 72 having mounted therein an adjustable abutment or stop abutment 74. The stop comprises merely a threaded stud or set screw threadedly traversing the flange or lug 72 and carrying a lock nut 76. The abutment screw 74 normally bears against the upper surface of the second pivoted arm or lever of the adjustable bell crank designated by the reference numeral 77 of the drawings and bearing at its end a roller follower 78 journaled in opposed, anti-friction bearings 80.

The opposite extremity 82 of lever 76 is likewise pivotal on shaft 22. The two relatively movable arms of the bell crank assembly are normally maintained in the relative position shown in Figs. 2 and 4 by a cantilever leaf spring assembly 84 mounted in the lower portion of the housing, as clearly shown in Figs. 2 to 6, by means including the parts shown in Fig. 8. It is particularly to be noted that the leaf comprises a series of superposed spring leaves, each of the successively lower leaves being spaced at increased distance from the free extremity of the spring. The spring leaves thus formed are mounted upon an insert within the housing, which insert or frame is designated by the reference numeral 86 and permanently fastened by means not fully disclosed in the position shown in Figs. 2 and 4. As shown more in detail in Figs. 2, 4, 5, 6 and 8, the lower surface of the frame or partition 86 mounts a clamping block 88 bifurcated throughout most of its length to provide opposed spring embracing walls 90 integrally connected at the left hand end, as viewed in Fig. 8, by an abutment portion 92.

The block just above the abutment portion 92 is slotted as at 94 to receive the bundle of spring leaves. The block with the spring bundle mounted therein is clamped to the frame 86 by a lower attachment block 96 provided with an inclined slot 98 which cooperates with a complementary slot 100 within the frame member 86 to receive the rectangular marginal boundaries of the block 88. Machine screws 102 extend through the block 96, as clearly shown in Figs. 2 and 4, to permanently clampingly associate the parts and it will be noted that the upper surface of the

frame 86 is provided with inclined or milled slots 104 to facilitate application in the tightening of the fastener.

Attention is moreover directed to the fact that the present spring assembly is provided with a spring bearing block 104 slidable longitudinally in the guideway between the two spaced guide walls 90 of the block 88 and accordingly just beneath the lowermost leaf of the cantilever spring 84. The bearing block 105 is movable in response to the threaded control bar 106 received within a complementary threaded aperture in the supporting block 105 and journaled in axially fixed relationship within the transversely extending portion 92 of the block 88. To this end the threaded control bar 106 has a rigid collar 108 cooperating with a kerfed or slotted head 110 for oppositely embracing the transverse portion 92 of the block 88. As clearly shown in Figs. 2 and 4, the slotted head 110 is permanently pinned to the control bar 106 as indicated at 112.

It will be obvious from the foregoing that the effective length of the cantilever spring may be adjusted to any predetermined value merely by rotational adjustment of the slotted head 110 to slide the bearing block 105 longitudinally of the spring. Accordingly, as the bearing block 105 moves to the right, as viewed in Fig. 2, the deflection rate of the spring decreases, whereas movement of the bearing block to the left results in an increased facility of deflection and accordingly a corresponding decrease in the spring resistance counter-acting the centrifugal force resultants of the centrifugal weights 52.

From the foregoing it will be understood that the present invention contemplates the constant rotational actuation of the shaft 30 and accordingly the centrifugally responsive assembly including the weights 52 at a speed equal to or corresponding to the rotational speed of the engine 14. The centrifugal force set up by the weights 52 is applied through the agency of lever extremities 56 to the sleeve 60 and the bell crank lever assembly 64 and 76. The forces thus created by the action of the centrifugal weights are imposed upon the cantilever spring 84 through the agency of the roller follower 78 which, as clearly shown in Figs. 2 and 4, rides directly upon the upper leaf of the cantilever spring 84. In other words, the upper surface of the cantilever spring provides a track upon which the roller 78 bears and runs throughout its operative path of movement.

Cooperation of these parts is obviously enabled by virtue of a central aperture or cut-away portion 114 in the frame 86. Thus it should be particularly noted that with the parts in normal position, as shown in Fig. 2, the roller follower 78 resides adjacent the outer-most limit or extremity of the cantilever spring, where the resisting spring tension is relatively minor. As the centrifugal weights, however, come into action to limiting speed of the engine, or, in other words, as they approach the position shown in Fig. 4, the rotational shifting of the center of the roller follower 78 has resulted in movement of the roller inwardly beyond the free extremity of the spring, thus, in effect, shortening the effective length of the spring, decreasing the deflection rate, and accordingly rapidly increasing or building up the rate of spring resistance.

It will be apparent that the position of the unbalanced valve 16 is determined by the angular position of the shaft 22, which shaft, in turn, is determined in accordance with the im-

position of the centrifugal force resultants upon the spring 84.

Particular attention is directed to the fact that as the lever roller deflects the spring there are three factors which progressively tend to increase the spring resistance. First of all, the deflection of the cantilever spring per unit load is proportionate to the cube of the effective length. In the second place, the deflection of a cantilever spring is diminished if two or more of the top leaves are of equal length. While the present spring following the necessities for ideal design has evenly graduated leaves, nevertheless the roller, in moving to the left, progressively reaches a point or points wherein the top leaves have the same effective length. In other words, the roller, in moving to the left, brings the point of force application ultimately to positions where two or more leaves lie in contiguity.

As a further factor, it will be noted that the moment of the imposed force about the point of support of the spring is reduced as the roller moves inwardly. Accordingly, as the roller travels inwardly from the free end of the spring, the resistance of the spring not only increases, but does so in accordance with a characteristic plan which is particularly favorable to the operation of the centrifugal governor of the present class. Moreover, these factors permit the desired variation in spring resistance with a minimum of spring deflection to the end that a new and improved compactness of design is permitted.

That is to say, the present invention permits the use of a lighter and smaller cantilever spring. This will be readily apparent from a consideration of the chart of Fig. 9 wherein the curve H indicates the spring characteristics of a cantilever spring loaded at the extremity in accordance with the teaching of the foregoing Krebs patent. In accordance with the chart, it will be evident that the coordinates represent the angular movement of the flyweights plotted against the corresponding spring tension exerted and expressed in terms of the torque transmitted to the crank pivot. The curve C shows the comparative characteristics of the same spring with the centrifugal force resultants applied by means of the bell crank lever hereinbefore described. Thus the load curve of the latter spring assembly is 40 per cent higher at maximum deflection than where the load is imposed at the end of the spring.

It should be particularly noted that this is an important consideration in the present art where the available space is limited and the over-all dimensions of the structure are determined by the spring length.

It should furthermore be noted, as pointed out above, that the spring load curve, in accordance with the present invention, rises at an increasing rate as maximum deflection is approached, in a manner which is particularly adapted to meet the demands of centrifugal governor construction. Thus, it has been found that in order to avoid instability of governing action it is necessary to assure a no-load speed slightly in excess of the full-load speed. To meet this condition the spring load force must at no-load position be slightly in excess of the resultants of the centrifugal forces which would be imposed on the spring if the no-load speed were the same as the full-load speed. So, also, the amount of unbalance or variation between the spring resistance and the centrifugal force imposed at un-

varying speed may advantageously increase more rapidly as the no-load position of the mechanism is approached for the reason that frictional resistance, which is one of the prime causes of hunting, surging, or other instability of the governor, increases toward no-load position. In other words, the external work the governor must do in overcoming frictional resistance of throttle movement is greatest at no-load position, and a greater stabilization factor is required in that position.

It will be appreciated moreover by those skilled in the art that since uniform increments of valve movement result in non-uniform variations of developed power, it is thus ordinarily necessary to provide for a more rapid movement of the governor throttle valve with respect to the movement of the fly weights, in the nearly-open range of throttle than in the nearly-closed range. But if at the open, or substantially open range of throttle movement the governor is nearly isochronous, relative movement of the fly weights and throttle valve are not of great significance. As is known in the art, isochronism is the result of conformance of the resultants of the centrifugal force with the spring resistance for all throttle positions at a fixed and unvarying speed.

In accordance with the present invention, the centrifugal force resultants are imposed upon the spring in accordance with the foregoing principles. Thus, referring to Fig. 9 of the drawings, curves A, C and H are spring loading curves for springs constructed as shown in the foregoing drawings, the curves being taken for various governed engine speeds and over a range of fly weight movement equivalent to the necessary range of movement of the throttle valve. Thus curve A represents the spring loading characteristics at a governed speed of 2,000 R. P. M., whereas curves C and H indicate the same characteristics at 1,700 R. P. M. and 1,000 R. P. M., respectively. The centrifugal force resultants for the same condition of the fly weights are represented by curves B, D and F, the curves being taken at governed engine speeds of 2,000 R. P. M., 1,700 R. P. M., and 1,000 R. P. M., respectively.

It is of particular significance to note that the spring load curves in the nearly open position of the throttle valves conform relatively closely with the curve of centrifugal force resultants at unvarying speed. Thus, for example, the lower portion of curve A conforms very closely to the left-hand portion of the corresponding curve B and it will be appreciated that the correspondence of these two curves is even closer if the necessary increase of speed is taken into consideration. In short, the close correspondence of these curves illustrates the manner in which the present invention provides an ideal condition in the range where frictional resistances are at a minimum and hunting or surging is avoidable with a minimum stabilization factor. On the other hand, from the increasing divergency of the curves A and B adjacent their upper or right-hand portions, it will be evident that an increasing stabilization factor is automatically made available where an increased stabilization is necessary. In other words, the present method of yieldably resisting the centrifugal forces operates to automatically vary the stabilization factor in accordance with the inherent demands of the device.

It is thought pertinent to direct particular at-

tention to the improved results available through use of the adjustable bell crank lever assembly designated by reference numerals 64 and 76 in including the adjustable set or stop screw 74 for varying the angular spacing of the two arms of the lever. Thus the main adjustment means represented by the shiftable spring support 104 merely varies the effective length of the spring for causing a corresponding variation in the load carrying rate for a given deflection.

On the other hand, as the effective length of the spring is diminished by this means, the spring in becoming shorter provides a relatively sharper increase in load carrying rate. In other words, as the length of the spring decreases, the rate of change in spring resistance may tend to become somewhat in excess of requirements, particularly at high governed speed ranges and particularly if a high degree of accuracy is required at such high governed speeds. For this reason it is desirable to control the relative characteristics of the spring and centrifugal resultants as mutually opposed. Attention is directed to the fact that this factor is under complete control in accordance with the principles of the present invention.

Thus, referring again to Fig. 9, it will be noted that the dotted line curves B, D, and F, for example, show the centrifugal force resultants for the isochronous condition. On the other hand, the solid line curves represent the spring loading at various corresponding speeds and adjustments. In operation, of course, the spring forces of the governor exactly balance the centrifugal force resultant in any position of the fly weights when the speed and load are unchanging and accordingly determines the position of the throttle valve 16. Thus, it should be noted that at full load speed of 1,700 R. P. M., as represented by spring force curve C and the associated curves D of centrifugal force resultants, there is a relatively wide divergence in the curves as the spring tension increases. If the governor adjusted for such operation be now subjected to relative adjustment of the bell crank lever construction, the following change will occur: For example, as the set screw 74 is tightened to move the lower arm 76 of the bell crank relatively downwardly, an increased tension of the spring results to increase the governed speed of the engine. Without any material change, therefore, in the deflection rate of the spring since the effective rate remains substantially the same, the spring tension is increased for all relative positions of the parts. That is to say, for all angular positions of the fly weights the spring exerts substantially increased increments of resistance, which increments, it is particularly important to note, are substantially uniform.

For the next position of the foregoing, attention is respectfully directed to a comparison of curves A and C, the former curve representing the characteristic action of the spring adjusted for a governed speed of 2,000 R. P. M. from the former position of the parts represented by the curve C by tensioning of the auxiliary bell crank lever adjustment. It should be particularly noted that the spring loading curve A is approximately parallel to the curve C. That is to say, while the curve C diverges from the isochronous curve B corresponding to the same controlled speed of the engine, the curve A quite closely approaches the corresponding isochronous curve B. Thus ability to control the rate and characteristics of increase in spring tension renders the

present invention applicable with any desired degree of accuracy to the respective isochronous centrifugal force curve.

Stated in another way, the normal divergence in centrifugal force curves, such as represented by relative inclination of the curves B and D, may be compensated in accordance with the present invention by correspondingly controlling the general inclination of the spring loading characteristics at any speed. In short, by maintaining curve A approximately parallel to curve C while the curve of the isochronous condition meanwhile shows an increase in rate of change, the final factors are brought into sufficiently close agreement to assure an improved governor control. Thus the maximum divergency of the upper part of curves A and B represents less than a 5 per cent variation in speed from no-load to full-load.

It will be understood by those skilled in the art that the foregoing curves illustrate the manner in which the accuracy and stability of governor action are under precise control by the present dual adjustment. Thus, for substantially any desired governor speed, the spring characteristics are relatively adjustable to comply as precisely as desirable to the isochronous condition for that speed. Thus, for a speed of 1,700 R. P. M., the centrifugal force resultants and spring tension characteristics may be brought into as close agreement as desired.

The foregoing represents an important practical advantage of the present invention rendering the device adaptable to close and accurate engine control. The important of this improvement will be understood from a consideration of curve H, Fig. 9, showing the characteristics of the spring which is now under consideration. With the forces imposed at the extreme free end thereof it will be noted that this curve is a straight line having no desirable relation to the theoretically necessary conditions for proper governor control.

I have found in general that the most accurate setting is obtained by employing the greatest possible length of cantilever spring with the maximum possible tensioning of the bell crank control. Any resultant tendency to instability resulting from inordinate accuracy of control is then easily corrected by relaxing the tension of the bell crank lever control and using the main adjustment to stiffen the spring. Accordingly, the present device may be rapidly and efficiently adjusted by relatively un-skilled persons to give the highest possible degree of practical engine speed control without such adverse conditions known as bucking, hunting or surging. Accordingly, therefore, the present governor is of practical importance in being adjustable in accordance with each particular engine.

It is thought pertinent to further point out that the curves of centrifugal force resultants shown in Fig. 9 are not exactly straight lines, due to the fact that the resultants as imposed on the spring are referred to the axis of oscillation of the fly weights. The present invention contemplates proportioning of the parts so that the centers of gravity of the fly weights are permitted ample control movement without passing the point of maximum moment, in order that the characteristic variation in centrifugal force resultants imposed on the spring follow the characteristics indicated in Fig. 9. That is to say, if the fly weights were permitted to act past the point of maximum moment the characteristics of the ap-

plied resultant centrifugal force would experience an irregular variation at this point. Accordingly, by restraining the fly weights for action within restricted limits, centrifugal force resultants become so nearly identical to corresponding spring resistances that at some points in the range of adjustment the governor performance may be for all practical purposes isochronous.

Attention is particularly drawn to the fact that in accordance with the present construction the flyweights are pivoted about axes of oscillation which are displaced outwardly a substantial distance in the axis of rotation of the governor shaft 30. In other words, the pivots 50 about which the flyweights oscillate are laterally spaced a distance beyond the center of gravity of the flyweights throughout the path of oscillation. This structure is of important practical significance in that it results in a force curve of centrifugal resultants about the pivot point which correspond quite closely to the spring characteristics of the cantilever spring and roller follower construction. Thus, comparing this construction to, for example, a construction wherein the flyweights shift through a path such that their centers of gravity extend substantially beyond the axis of oscillation, it will be seen that a sharp distinction exists. Thus, in the latter case, the force curve tends to convexity in an upward direction whereas with the present structure the force curve substantially coincides with the spring characteristics. It will be obvious therefore that the present structure is ideally suited to making an accurate governor in combination with a cantilever spring. It is furthermore important to point out that the supported end of the cantilever spring 84 is disposed in a line extending inwardly of the crank roller 80 and accordingly the spring is flexed by the roller even when the parts are in normal position of quiescence whereby a substantial initial spring tension is exerted upon the crank arm. This insures that the spring exerts an initial predetermined force against the flyweight spindle so that the cut-off point when the control valve starts to move will be at a speed approximating the no-load speed.

It will be apparent from the foregoing that the present invention provides a centrifugal governor which meets the demands of the art in that it is capable of regulating the speed of an engine over a wide range of possible adjusted speeds while, at the same time, it is capable of adjustment of extraordinary accuracy in relation to any particular speed. Heretofore governors materially sacrificed accuracy of control in order to provide constructions capable of more than a limited speed variability. So, too, such devices have tended to become inordinately bulky and space-consuming. The present invention provides a device which may be extremely compact and which permits the operator to vary the governor speed as desired.

It is thought that the invention and numerous of its attendant advantages will be understood from the foregoing description and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein described being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. A centrifugal governor comprising centrifugal means adapted to rotate about a predeter-

mined axis in response to engine speed, and including a flyweight shiftable about an axis of oscillation toward and away from the said axis of rotation, means to adjustably position a throttle valve comprising a yieldable, elongated spring member mounted on a support, means to impose the centrifugal force resultants about said axis of oscillation upon the yieldable member comprising a crank means disposed in lateral contacting relation with said spring and shiftable by said force resultants in a path laterally of the spring to progressively deflect the spring, said axis of oscillation being located outside the center of gravity of the flyweight throughout its operative path of movement.

2. A centrifugal governor comprising centrifugal means adapted to rotate about a predetermined axis in response to engine speed, and including a flyweight shiftable about an axis of oscillation toward and away from the said axis of rotation, means to adjustably position a throttle valve comprising a yieldable, elongated spring member mounted on a support, means to impose the centrifugal force resultants about said axis of oscillation upon the yieldable member comprising a crank means disposed in lateral contacting relation with said spring and shiftable by said force resultants in a path laterally of the spring to progressively deflect the spring, said axis of oscillation being located outside the center of gravity of the flyweight throughout its operative path of movement, said yieldable member comprising a cantilever spring supported adjacent one extremity only.

3. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a control member comprising a yieldable elongated spring fixedly supported at one end and means to impose the centrifugal force resultants of said centrifugal means upon the yieldable spring comprising spring impinging means movable along the lateral face of said spring in lateral contacting relationship and shiftable by said force resultants in a predetermined path extending transversely of the spring in a direction to progressively laterally deflect the spring while extending longitudinally of the spring toward the point of support whereby said centrifugal force resultants are applied to the spring at a point progressively approaching the spring support with an increase in said resultants.

4. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a throttle valve comprising a yieldable, elongated spring member mounted on a support, means to impose the centrifugal force resultants of said centrifugal means upon the yieldable member comprising a crank means disposed in lateral contacting relation with said spring and shiftable by said force resultants in a path laterally of the spring to progressively deflect the spring laterally and to move longitudinally thereof, the parts being positioned and arranged so that the point of contact with the spring approaches the spring support with an increase in centrifugal force resultants, and means for adjusting the governing speed of said governor assembly comprising means for relatively angularly adjusting the crank means.

5. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a throttle valve comprising a yieldable, elongated

spring member mounted on a support, means to impose the centrifugal force resultants of said centrifugal means upon the yieldable member comprising a crank means disposed in lateral contacting relation with said spring and shiftable by said force resultants in a path laterally of the spring to progressively deflect the spring laterally and to move longitudinally thereof, the parts being positioned and arranged so that the point of contact with the spring approaches the spring support with an increase in centrifugal force resultants, and means for adjusting the governing speed of said governor assembly comprising means for relatively adjusting the crank and spring to vary the spring resistance in substantially equal amounts throughout the path of operation of said crank means.

6. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a throttle valve comprising a yieldable, elongated spring member mounted on a support, means to impose the centrifugal force resultants of said centrifugal means upon the yieldable member comprising a crank means disposed in lateral contacting relation with said spring and shiftable by said force resultants in a path laterally of the spring to progressively deflect the spring laterally and to move longitudinally thereof, the parts being positioned and arranged so that the point of contact with the spring approaches the spring support with an increase in centrifugal force resultants, means for adjusting the governing speed of said governor assembly comprising means for relatively adjusting the crank and spring to vary the spring resistance in substantially equal amounts throughout the path of operation of said crank means, and auxiliary means for providing a multi-speed governor control comprising means for varying the length of the yieldable spring with respect to the spring support.

7. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a throttle valve comprising a yieldable, elongated spring member mounted on a support, means to impose the centrifugal force resultants of said centrifugal means upon the yieldable member comprising a crank means disposed in lateral contacting relation with said spring and shiftable by said force resultants in a path laterally of the spring to progressively deflect the spring laterally and to move longitudinally thereof, the parts being positioned and arranged so that the point of contact with the spring approaches the spring support with an increase in centrifugal force, said crank means being operatively shiftable through a predetermined angular range by application of said centrifugal force resultants, and means for angularly varying the relative angular location of said angular range of action and operative to predetermine the governed speed of an associated engine.

8. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a throttle valve comprising a yieldable, elongated spring member mounted on a support, means to impose the centrifugal force resultants of said centrifugal means upon the yieldable member comprising a crank means disposed in lateral contacting relation with said spring and shiftable by said force resultants in a path laterally of the spring to progressively deflect the spring laterally

and to move longitudinally thereof, the parts being positioned and arranged so that the point of contact with the spring approaches the spring support with an increase in centrifugal force, said crank means being operatively shiftable through a predetermined angular range by application of said centrifugal force resultants, and means for angularly varying the relative angular location of said angular range of action and operative to predetermine the governed speed of an associated engine, said last-named means comprising an adjustable bell crank control adjustable for determining the relative angular disposition of the arms of the bell crank.

9. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a throttle valve comprising a yieldable, elongated spring member mounted on a support, means to impose the centrifugal force resultants of said centrifugal means upon the yieldable member comprising a crank means disposed in lateral contacting relation with said spring and shiftable by said force resultants in a path laterally of the spring to progressively deflect the spring laterally and to move longitudinally thereof, the parts being positioned and arranged so that the point of contact with the spring approaches the spring support with an increase in centrifugal force, said crank means being operatively shiftable through a predetermined angular range by application of said centrifugal force resultants, and means for angularly varying the relative angular location of said angular range of action and operative to predetermine the governed speed of an associated engine, said last-named means comprising means for applying said centrifugal force resultants for rotating said crank means, and means for varying the angular relation between the point of application of said centrifugal force resultants and the crank means.

10. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a throttle valve comprising a yieldable, elongated spring member mounted on a support, means to impose the centrifugal force resultants of said centrifugal means upon the yieldable member comprising a crank means shiftable by said force resultants and having an outer portion adapted to progressively deflect the spring laterally and to move longitudinally thereof, the parts being positioned and arranged so that the point of contact with the spring approaches the spring support with an increase in centrifugal force, said crank means being operatively shiftable through a predetermined angular range by application of said centrifugal force resultants, means for angularly varying the relative angular location of said angular range of action and operative to predetermine the governed speed of an associated engine, said last-named means comprising means for applying said centrifugal force resultants for rotating said crank means, means for varying the angular relation between the point of application of said centrifugal force resultants and the crank means, and additional means for adjusting the governor speed comprising means for varying the length of said spring with respect to said support.

11. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a throttle valve comprising a yieldable, elongated spring member mounted on a support, means to impose the centrifugal force resultants of said

centrifugal means upon the yieldable member comprising a crank means shiftable by said force resultants and having an outer portion adapted to progressively deflect the spring laterally and to move longitudinally thereof, the parts being positioned and arranged so that the point of contact with the spring approaches the spring support with an increase in centrifugal force, said crank means being operatively shiftable through a predetermined angular range by application of said centrifugal force resultants, means for angularly varying the relative angular location of said angular range of action and operative to predetermine the governed speed of an associated engine, said last-named means comprising means for applying said centrifugal force resultants for rotating said crank means, means for varying the angular relation between the point of application of said centrifugal force resultants and the crank means, and additional means for adjusting the governor speed comprising a spring support longitudinally movable with respect to the spring for varying the effective length thereof.

12. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed and including a flyweight, pivot means mounting said flyweight for movement toward and away from the axis of rotation of said centrifugal means, said pivot being located radially outwardly beyond the center of gravity of said flyweight throughout its path of movement, means to adjustably position a control member comprising a yieldable elongated spring supported at one end and means to impose the centrifugal force resultants at said pivot upon the yieldable spring comprising spring impinging means movable along the lateral face of said spring in lateral contacting relationship and shiftable by said force resultants in a predetermined path extending transversely of the spring in a direction to progressively laterally deflect the spring while extending longitudinally of the spring toward the point of support whereby said centrifugal force resultants are applied to the spring at a point progressively approaching the spring support with an increase in said resultants.

13. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a control member comprising a yieldable elongated spring supported at one end and means to impose the centrifugal force resultants of said centrifugal means upon the yieldable spring comprising spring impinging means movable along the lateral face of said spring in lateral contacting relationship and shiftable by said force resultants in a predetermined path extending transversely of the spring in a direction to progressively laterally deflect the spring while extending longitudinally of the spring toward the point of support whereby said centrifugal force resultants are applied to the spring at a point progressively approaching the spring support with an increase in said resultants, and means for adjusting said spring impinging means relative to said centrifugal means in said path of the spring impinging means whereby to vary the spring tension applied to said spring impinging member in substantially equal amounts throughout said path of movement.

14. In a centrifugal governor comprising centrifugal means adapted to operate in response to engine speed, means to adjustably position a control member comprising a yieldable elongated spring supported at one end and means to impose

the centrifugal force resultants of said centrifugal means upon the yieldable spring comprising spring impinging means movable along the lateral face of said spring in laterally contacting relationship and shiftable by said force resultants in a predetermined path extending transversely of the spring in a direction to progressively laterally deflect the spring while extending longitudinally of the spring toward the point of support, where-

by said centrifugal force resultants are applied to the spring at a point progressively approaching the spring support with an increase in said resultants, said spring being supported at said one end in a line extending inwardly of said spring impinging means in normal position whereby to set up an initial predetermined spring resistance.

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