

May 17, 1938.

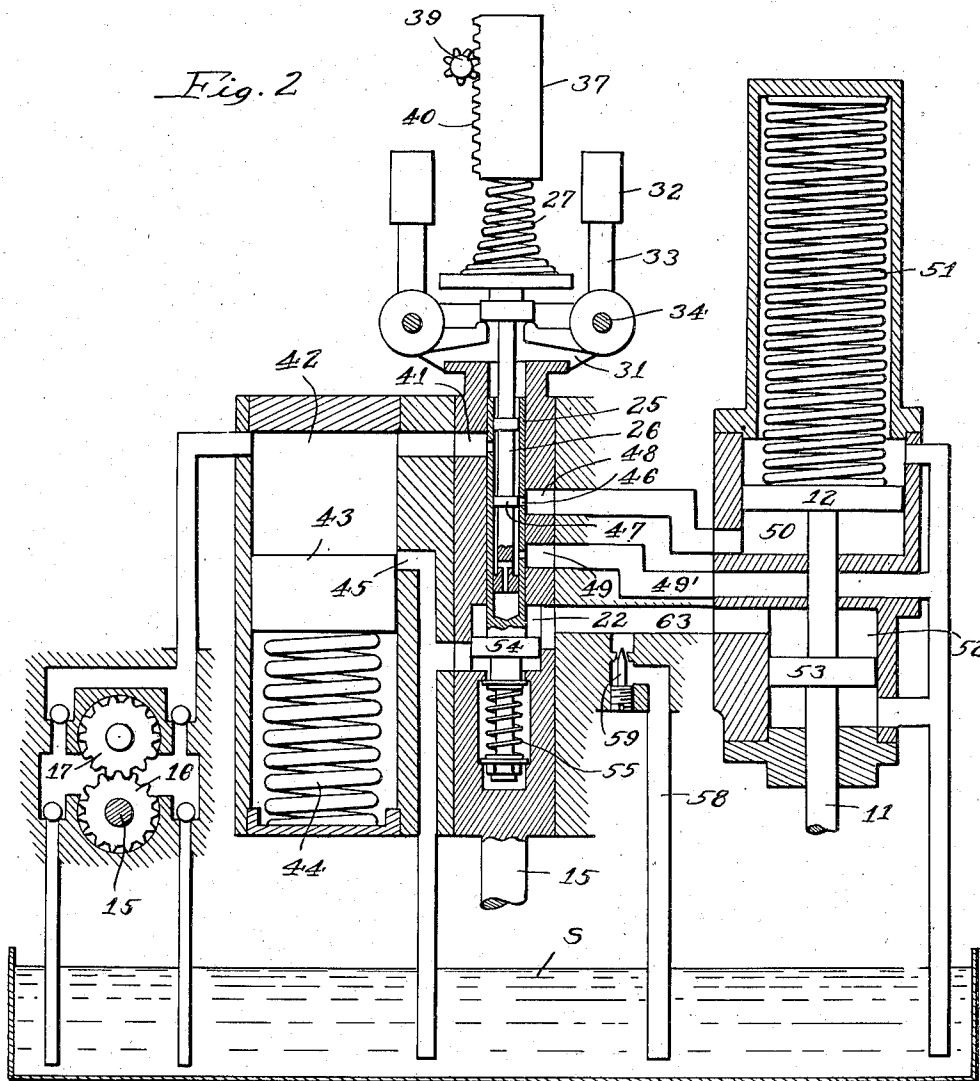
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2,117,891

GOVERNOR

Filed June 17, 1935

4 Sheets-Sheet 2



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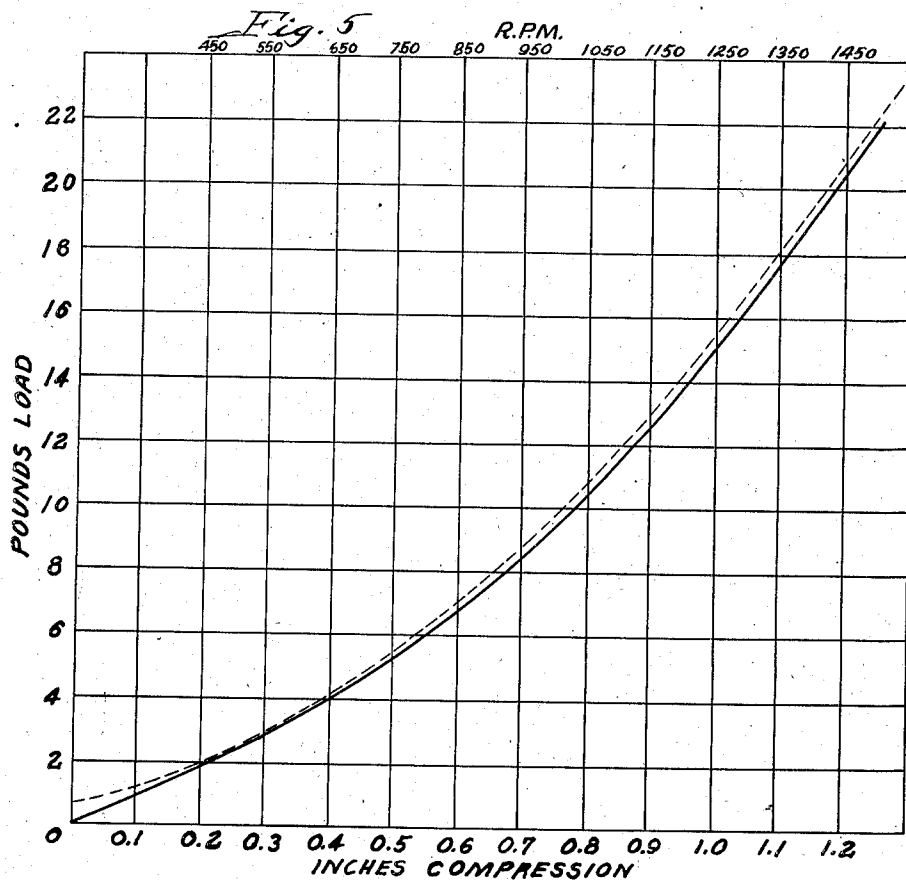


Fig. 3

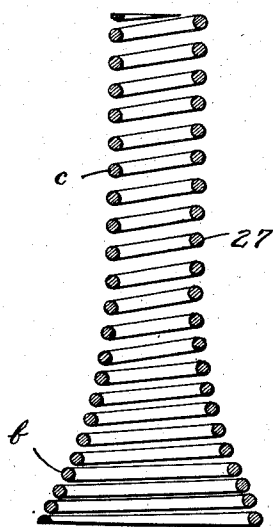
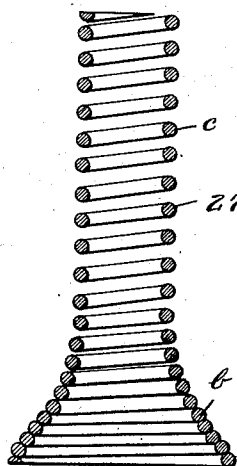


Fig. 4



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Fig. 6

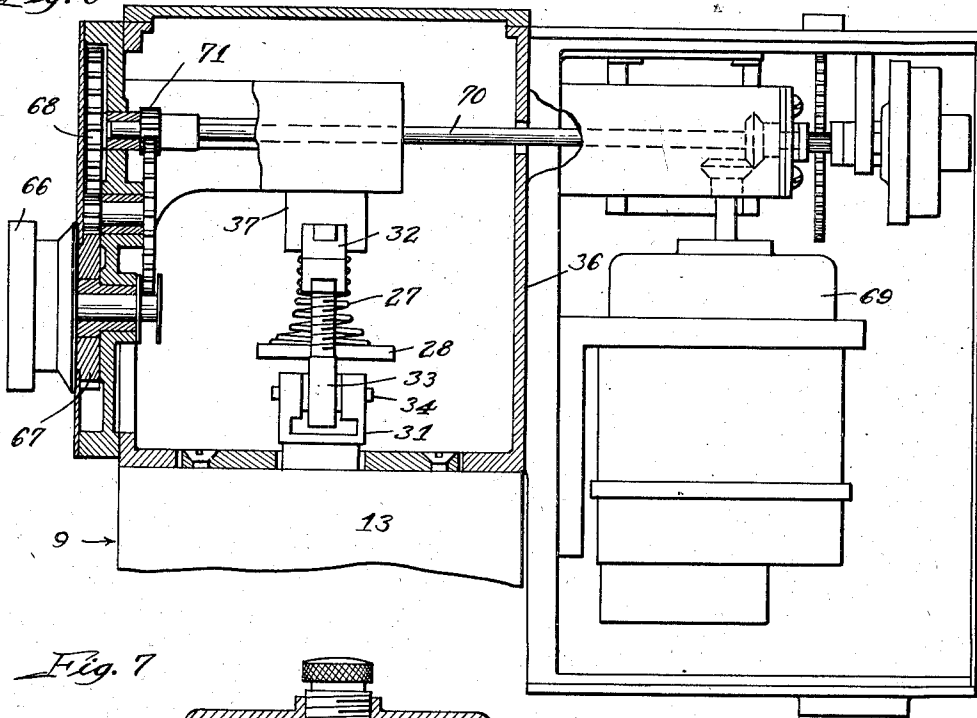
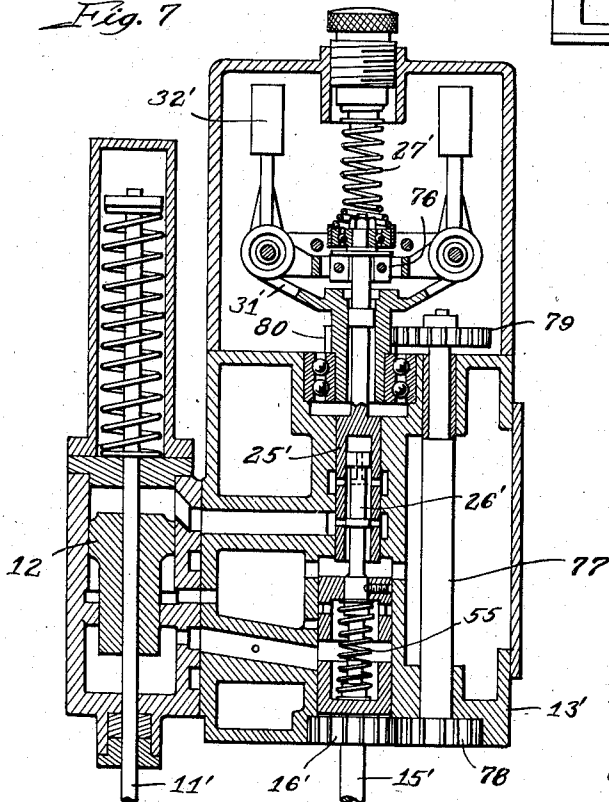


Fig. 7



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UNITED STATES PATENT OFFICE

2,117,891

GOVERNOR

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4 Claims. (Cl. 264—15)

This invention relates to speed governors for prime movers in power plants.

The conventional type of fly-ball governors, due to their faulty design and construction, have not given satisfactory speed regulation. For one thing, these earlier governors have not been constructed so that the speed weighing or fly-ball elements would respond the same amount for any given percentage of speed change over the entire range of operating speeds. It is the principal object of my invention to provide what I call a "trumpet" spring as the speeder spring in the fly-ball mechanism of the governor, whose deflection is proportional to the square root of the deflecting force, thereby producing a relationship between loading and deflection of precisely the same nature as the relationship between centrifugal force and speed.

The spring, in accordance with my invention, is obtained by graduating the pitch of the turns and the diameter of the coiling so that as the loading on the spring is increased, the large diameter turns progressively completely close, thereby causing the spring modulus to increase in proportion to the deflection. By graduating the diameter of coiling, the modulus is caused to change gradually in proportion to the deflection. The novel characteristics of this spring make for better regulation with this governor because the changing modulus of the spring counteracts or offsets the change in centrifugal force of the fly-balls as they move outwardly due to load rejection, and inwardly due to load application.

The invention is illustrated in the accompanying drawings in which—

Figure 1 is a longitudinal section through a governor made in accordance with my invention;

Fig. 2 is a diagrammatic drawing of the governor;

Fig. 3 is a longitudinal section through the speeder spring made in accordance with my invention;

Fig. 4 shows the same spring under load;

Fig. 5 is a curve showing the characteristics of the spring;

Fig. 6 is a view partly in side elevation and partly in section showing the application to the governor of manually operable and motor operable speed adjusting means, and

Fig. 7 is a section through another governor showing a modified or alternative construction.

Similar reference numerals are applied to corresponding parts throughout the views.

Referring first to Figures 1–5 and Figures 1 and 2 in particular, the coupling 8 serves to connect the

governor 9 to the prime mover, the speed of which is to be regulated. The clevis 10 on the end of the rod 11 of the power piston 12 will be suitably connected to open or close the throttle of the engine, namely, the aforesaid prime mover. The governor comprises a main body 13 mounted on a base 14 suitably supported on the prime mover. A shaft 15 extends from the coupling 8 through a bearing and grease retainer in the base 14 into the body 13 where it is splined to the drive gear 16 of a gear pump, the companion gear of which is numbered 17. A long bushing 18 extending the full length of the body 13 and rotatable in the central longitudinal bore 19 thereof is fixed to the hub of the gear 16, as at 20, so as to be driven by the shaft 15. The bushing 18 has a longitudinal bore 21 which terminates in a cylinder 22 formed in the lower end of the bushing. A sleeve 23 forms a closure for the lower end of the cylinder 22 and is fixed to the bushing 18, as at 24. A pilot valve bushing 25 is slidable lengthwise in the bore 21 and is arranged to turn with the bushing 18 relative to the pilot valve plunger 26 which fits in the bushing 25. The pilot valve plunger 26 is non-rotatable along with the speeder spring 27 which seats on the collar 28 that is clamped by a nut 29 threading on the upper end of the plunger 26. The inner race of a ball bearing 30 is clamped to the plunger 26 by the collar 28, the outer race of the bearing being arranged to turn with the yoke 31 of the fly-ball mechanism. Each of the fly-balls 32 in this governor is formed by two nuts threading on one arm of a bell crank lever 33 pivoted at 34 on the yoke 31. The other arm of the lever bears against the outer race of the bearing 30, as shown. The yoke 31 is suitably fixed on the reduced upper end 35 of the bushing 18. The fly-ball mechanism is housed within the casing 36 mounted on the body 13 of the governor. The fly-balls 32 move outwardly under centrifugal force in the turning of the bushing 18 with the shaft 15 but are urged inwardly by the spring 27 to a greater or less extent, depending upon the position of the adjustable abutment for the spring indicated at 37. A screw plug 38 is adjusted in the initial assembling of the governor to place the spring 27 under a predetermined compression, and thereafter the governor is arranged to be adjusted in operation by movement of the abutment 37 by the turning of a pinion 39 which meshes with rack teeth 40 provided in one side of the abutment 37. The pinion 39, as will presently appear, may be operated directly by hand or by remote control. It is manifest that when the fly-balls 32 move out-

wardly, the pilot valve plunger 26 is raised. Inasmuch as such outward movement denotes an increase in speed, it is apparent that the upward movement of the pilot valve plunger 26 must, accordingly, effect such movement of the power piston 12 as will result in lessening the speed of the prime mover. Conversely downward movement of the pilot valve plunger 26 caused by a decrease in speed must cause the reverse movement of the piston 12 so as to increase the speed of the prime mover back to normal. Such operation is secured, as will now be described.

The gear pump 16—17 has the discharge side thereof communicating with the pressure port 41 through an accumulator 42, as indicated in Fig. 2. The latter has a piston 43 actuated by a spring 44 constantly by-passing oil through the port 45 to the sump S so as to maintain a relatively constant pressure at 41. The pilot valve bushing 25 and plunger 26 are normally in centered relation with the ports 46 in the bushing covered by the cylindrical enlargement 47 of the plunger. However, let us assume that a certain percentage of the load is dropped from the prime mover and that the latter accordingly speeds up and the fly-balls 32 move outwardly a distance proportionate to the speed change. The outward movement of the fly-balls forces the pilot valve plunger 26 upwardly a proportionate distance against the restraint of the speeder spring 27. The ports 46 are accordingly uncovered, opening communication between the port 48 in the bushing 18 and another port 49 in the bushing, whereby to allow the discharge of oil from the cylinder 50 from in front of the power piston 12 to the sump. The power piston 12 accordingly moves under the action of its spring 51 and since the rod 11, attached to the piston, is mechanically connected to the throttle or other energy medium control mechanism, said mechanism is accordingly operated in the direction to reduce the speed of the prime mover. Now, the movement of the piston 12 under the action of the spring 51 results in a suction being created in the cylinder 52 behind the actuating compensating plunger 53 and the pilot valve bushing 25 is accordingly moved upwardly by the receiving compensating plunger 54, which works in the cylinder 22 in the bushing 18. The upward movement of the plunger 54 is against the action of a double-acting spring 55 received in the sleeve 23 between two collets 56 and 57 slidably mounted on the reduced end of the pilot valve bushing 25. The collet 56 bottoms on the shouldered end of the sleeve 23 to resist the upward movement of the bushing 25 just described. The collet 57 bottoms on the adjacent end of the hub of the gear 16 to resist downward movement of the bushing 25. In the upward movement of the pilot valve bushing 25, because of the suction created in the cylinder 52, oil is drawn from the sump S through the passage 58 past an adjustable compensating needle valve 59, whereby to relieve the suction and also allow the compensating spring 55 to re-center the plunger 54. As the power piston 12 continues to move, the pilot valve bushing 25 moves upwardly until the ports 46 in the pilot valve bushing are again covered by the portion 47. The instant these ports are covered, the flow of oil from the cylinder 50 is stopped and the movement of the piston 12 will accordingly be stopped. If the ratio of movement of the governor parts is correct, the fuel delivery to the prime mover will have been re-

duced just the amount necessary to accommodate the reduced load and the speed will accordingly have returned to normal. It is only necessary, therefore, to keep this piston 12 stationary until the speed returns to normal or a subsequent speed change occurs. As the prime mover speed returns to normal, the fly-balls 32 will, of course, also return to their normal position and the pilot valve plunger 26 will return to its initial position. If the power piston 12 is to be kept stationary, the ports in the pilot valve bushing 46 must be kept covered by the portion 47 of the pilot valve bushing. Consequently, the pilot valve bushing must return to its central position in unison with the fly-balls 32 and the pilot valve plunger. This is accomplished by adjusting the flow of oil through the compensating needle valve 59 to permit the compensating spring 55 to re-center the compensating receiving plunger 54 and pilot valve bushing 25 in exact unison with the return of the prime mover speed to normal. Once the valve 59 has been adjusted to the response of the particular prime mover, it need not be adjusted again. All of the operating parts at the end of the cycle will accordingly be in the same position as before and only the power piston 12 will be shifted to a position corresponding to the reduced load on the prime mover.

The cycle of operation for an increase in load is simply the reverse of what has just been described. The fly-balls 32 move inwardly and the speeder spring 27 accordingly moves the pilot valve plunger 26 downwardly, uncovering the ports 46 and opening communication between the pressure port 41 and the cylinder 50, thus causing the power piston 12 to be moved in the opposite direction against the action of its spring 51. This movement of the power piston results in the creation of pressure in the cylinder 52 by reason of the movement of the actuating compensating plunger 53, and the receiving compensating plunger 54 is accordingly forced downwardly and moves the pilot valve bushing 25 downwardly until the ports 46 are covered by the portion 47 of the pilot valve plunger. The power piston 12 stops at the proper position to correspond to the increased load on the prime mover and the prime mover accordingly begins to return to its normal speed, thus causing the fly-balls 32 to move outwardly to their normal position, forcing the pilot valve plunger 26 upwardly toward its normal position. The compensating spring 55 re-centers the receiving compensating plunger 54 and pilot valve bushing 25 in exact unison with the return of the speed to normal by forcing the oil out to the sump past the needle valve 59. In that way, all of the operating parts resume their normal position and the power piston occupies a new position corresponding to the increased load.

It will be seen that I have provided a governor in which no levers are required in the regulating system and all of the regulating parts are on a common axis. The fact that the principal regulating parts, namely, the pilot valve bushing 25 and plunger 26, have relative rotation therebetween, the plunger being non-rotatable and fitting in the rotatable bushing, makes for greater sensitivity of regulation because sliding friction is thereby reduced to a minimum. Hunting is accordingly also avoided, although that is eliminated principally because of the novel self-centering action of the bushing with respect to the plunger.

The cylinders 50 and 52 for the power piston 12 and actuating compensating plunger 53, re-

spectively, are provided in a separate body 13a arranged to be bolted to the body 13 in any one of a number of positions of angular adjustment of the body 13a with respect to the body 13 accordingly as the particular engine may require the extension of the rod 11 downwardly, upwardly, horizontally, or otherwise. The body 13a is adjustable about the sump portion 49' as a center, and there are two annular grooves 60 and 61 formed in the abutting faces of the bodies 13 and 13a with this port 49' as a center. The sump S is formed by a chamber in the body 13 with which the port 49' communicates and the port 49 in the bushing also communicates through an opening 62. A passage 63 is cored in the body 13 to provide communication between the inner groove 60 and the cylinder 22, and inasmuch as the cylinder 52 communicates with the registering groove in the body 13a, it is apparent that communication is established between the cylinders 22 and 52 in any position of angular adjustment of the body 13a. In a similar manner, communication is established between the cylinder 50 and the port 48 in the bushing 18 through a passage 64 cored in the body 13 and communicating with the outer groove 61, the cylinder 50 having communication with the registering outer groove in the body 13a through a passage indicated in dotted lines at 65.

The speed adjustment for the governor is illustrated in Fig. 6 and comprises a manually rotatable knob 66 which turns a gear 67 arranged to operate the pinion 39 through intermediate gearing indicated at 68. A Selsyn motor 69 has a gearing connection with the shaft 70 extending past the spring abutment 37 on the opposite side from the pinion 39 and connected through other gearing, indicated at 71, with the gearing 68, whereby to turn the pinion 39 by remote control, it being understood that the Selsyn motor may be operated by the operator turning a controller at some remote point to obtain the same results so far as turning the pinion 39 is concerned as if the operator were to turn the knob 66 and thereby directly operate the speed adjustment mechanism.

The speeder spring 27 is illustrated in Figs. 3 and 4 and is one of the principal factors in obtaining better regulation with the present governor. I have named this spring a "trumpet" spring because of its trumpet-like shape, the one end b thereof being enlarged in a taper from the cylindrical portion c. This spring is so designed that for each given percentage of speed change it will allow the fly-balls 32 to move the same distance regardless of the base speed from which the increase occurs. In other words, the spring deflection is proportional to the square root of the deflecting force, thereby producing a relationship between loading and deflection of exactly the same nature as the relationship between centrifugal force and speed. The curves shown in Fig. 5 show the characteristics of this spring. The full line curve is plotted from spring loading against deflection and the dotted curve is plotted from fly-ball effort in pounds against speed of rotation. It will be noted that the two curves are parallel over a wide range. Therefore, if spring deflection is plotted against governor speed of rotation, a straight line results. I obtain these highly desirable characteristics in this spring by graduating the pitch of the turns and the diameter of the coiling in the flared portion b. Thus, as the loading on the spring is increased, these large diameter turns progressively close up, as

indicated in Fig. 4, thereby causing the spring modulus to increase in proportion to the deflection. By graduating the diameter of coiling, the modulus is caused to change gradually in proportion to the deflection. The changing modulus makes for better regulation in that it counteracts the change in centrifugal force of the fly-balls as they move outwardly due to load rejection and inwardly due to load application. The trumpet-shape is also highly desirable from the standpoint of simplified design and manufacture of the governor. It will be observed in Fig. 1, for example, what a compact construction is obtainable using this spring. Furthermore, the spring is mechanically self-supporting, that is, it requires no guiding but merely suitable support at both ends. While similar characteristics are obtainable in a cylindrical spring having turns of graduated pitch, the present construction is obviously far superior for the reasons pointed out.

In passing, attention is called to the fact that the fly-balls 32 are each formed by two nuts adjustably threaded on the bell crank levers 33, one nut serving as a lock nut for the other so as to maintain the adjustment. With this construction the fly-balls are not only adjustable but interchangeable, larger balls being used for slower speeds. The fly-balls are, of course, provided of the proper weight to suit the specifications of the engine for which the governor is intended, and will be adjusted at the factory of the governor manufacturer to provide for proper performance of the governor in accordance with the characteristics of the engine to which the governor is to be applied.

The governor shown in Fig. 7 is quite similar to the one previously described since it incorporates a speeder spring 27' having the same characteristics as the spring 27, and has provision for relative rotation between the bushing 25' and plunger 26' of the pilot valve. The bushing 25' and plunger 26' in this construction are differently related to the rest of the governor, the bushing 25' in this case being driven with the speeder mechanism through a connection at 76 with the speeder yoke 31', and the plunger 26' being non-rotatable but reciprocable with respect to the body 13' of the governor. The effect produced so far as reducing friction and making for greater sensitivity, and hence better regulation, is, however, substantially the same, except that somewhat less friction is involved in the rotation of the bushing 25' between the relatively stationary body 13' and plunger 26'. In this form of governor, the long bushing 18 forming a driving connection between the shaft 15 and the speeder yoke 31, as well as a housing for the pilot valve plunger and bushing, is eliminated, the driving connection in this case being afforded by a jack shaft 77 having a gear 78 at one end meshing with the gear 16' on the shaft 15', and another gear 79 at the other end meshing with gear teeth 80 on the speeder yoke 31'. The gears 16' and 68 together form a gear pump similarly as the gears 16 and 17 in the other governor. The operation of this governor is substantially the same as that of the other governor, the control rod 11' responding to movements of the fly-balls 32' in the same manner that the rod 11 responds to movements of the fly-balls 32.

It is believed the foregoing description conveys a good understanding of all of the objects and advantages of my invention. The appended claims have been drawn so as to cover all legitimate modifications and adaptations.

I claim:

1. In a fly-ball governor, a coiled speeder spring of trumpet shape having the turns at the flared end of gradually decreased pitch and arranged to close upon one another progressively as the compressive loading on the spring is increased, whereby to increase the modulus of said spring in proportion to the deflection.
2. A coiled compression spring having end turns of gradually decreased pitch and gradually increased diameter, said turns being so arranged whereby they close progressively inwardly from the large end upon compressive loading so that the spring modulus increases in proportion to the deflection.
3. In a fly-ball governor, a coiled speeder

spring of trumpet shape coiled from material of uniform cross-section and having the turns at the flared end of gradually decreased pitch and arranged to close upon one another progressively as the compressive loading on the spring is increased, whereby to increase the modulus of said spring in proportion to the deflection.

4. A coiled compression spring coiled from material of uniform cross-section and having end turns of gradually decreased pitch and gradually increased diameter, said turns being so arranged whereby they close progressively inwardly from the large end upon compressive loading so that the spring modulus increases in proportion to the deflection.

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