Sept. 21, 1926.

1,600,376

H. R. TROTTER

GOVERNOR

Filed Nov. 19, 1924

3 Sheets-Sheet 1

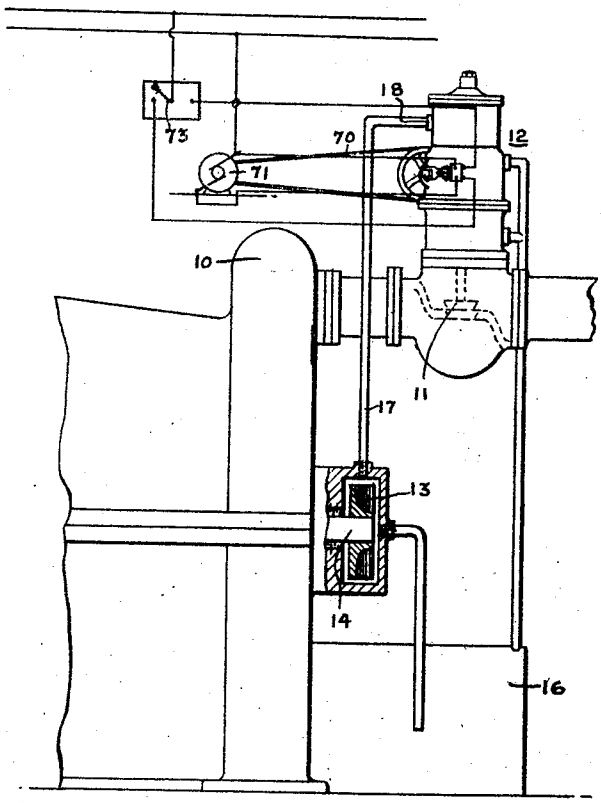


Fig. 1.

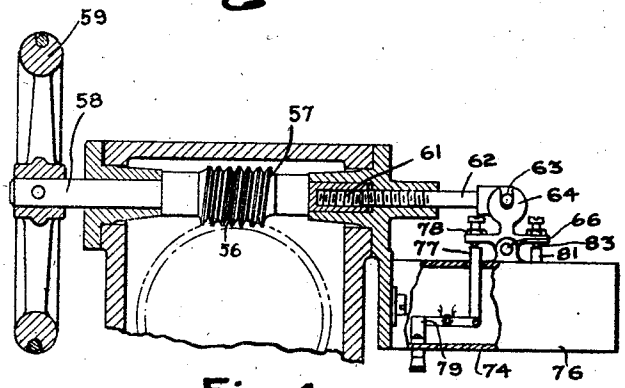


Fig. 4.

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3 Sheets-Sheet 2

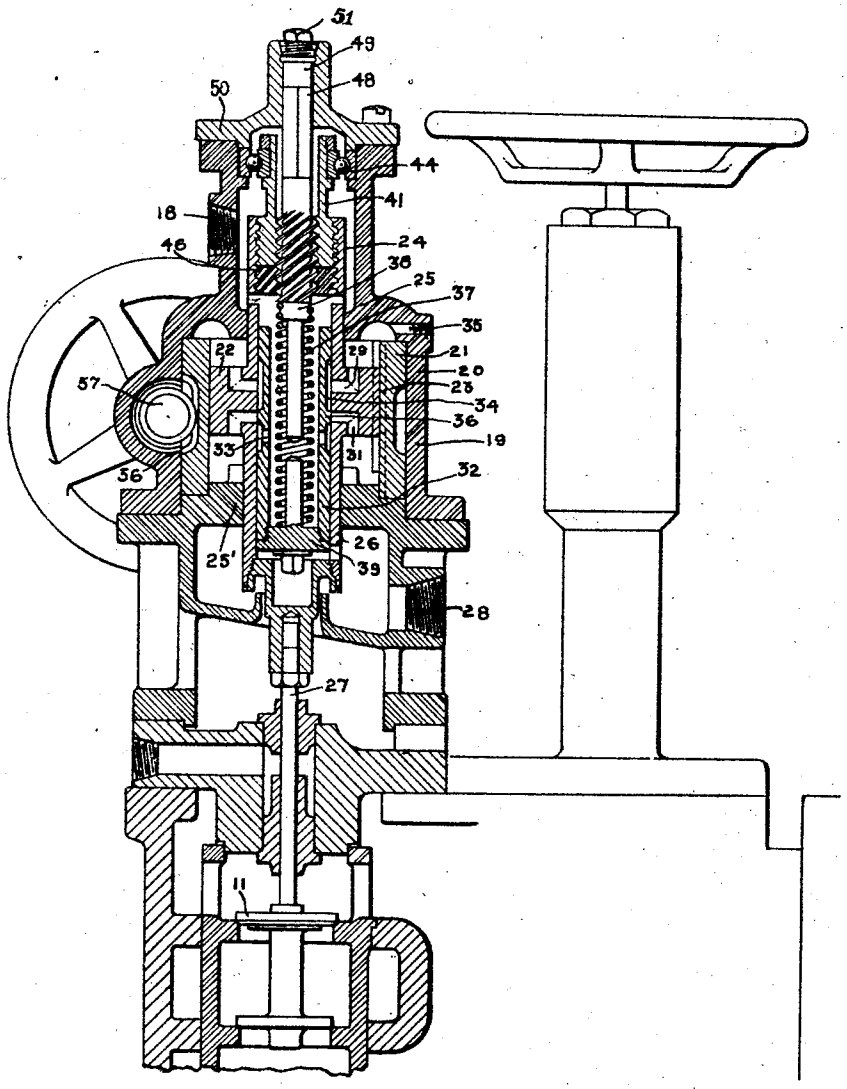


Fig. 2.

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3 Sheets-Sheet 3

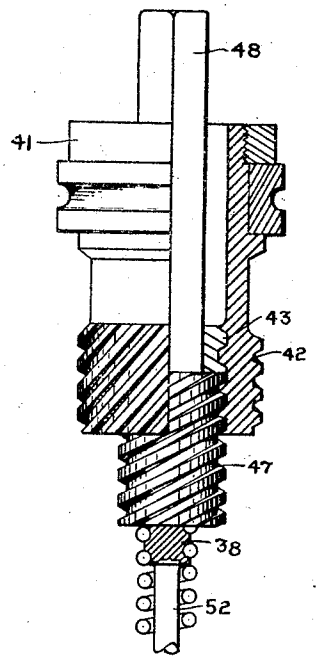


Fig. 3.

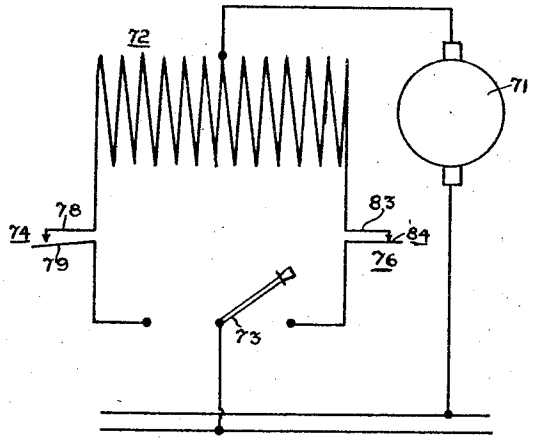


Fig. 5.

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UNITED STATES PATENT OFFICE.

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Application filed November 19, 1924. Serial No. 750,818.

My invention relates to variable fluid-pressure operated governing apparatus, more particularly to that class of apparatus embodying an element movable in response to variations in the fluid pressure in opposition to the force exerted by a spring and has for an object the provision of apparatus of the character designated which shall employ a spring of relatively small scale and at the same time effect wide ranges of movement of the element per unit of variation in the fluid pressure.

Another object of my invention is to provide, in apparatus of the character designated, simple, effective and readily accessible means for changing the initial tension of the spring, together with means for automatically limiting movements of the tension-changing means.

Apparatus embodying features of my invention is illustrated in the accompanying drawings forming a part of the specification and in which Fig. 1 shows an elastic fluid turbine equipped with my improved governing apparatus; Fig. 2 is a vertical sectional view of the governing apparatus; Fig. 3 is a sectional elevation of a screw motor employed in my invention; Fig. 4 is a sectional view of the speed changing mechanism; and Fig. 5 is a wiring diagram of a form of power limit stop which may be employed with my invention.

In the design of variable fluid-pressure operated governing apparatus embodying an element movable in response to variations in fluid pressure in opposition to the force exerted by a spring, difficulties have been encountered in that a spring of sufficient strength to withstand a relatively high fluid pressure must be employed and at the same time the spring must deflect sufficiently per relatively small unit of change in governing pressure to afford ample governing movements. Unless some means are employed to effect a relatively wide governing movement per unit of deflection of the spring, the spring employed is, of necessity, too long for practical purposes.

In accordance with my invention, I provide a mechanism for the spring retaining means or abutment, which effects a follow-up movement thereof at each movement of the element acted upon by the variable fluid pressure. In this manner, upon a change in fluid pressure, deflection of the spring and movement of the element, the spring retaining means also moves in the same direction, but at a slower rate, thus multiplying the effect of each deflection of the spring and providing a comparatively wide governing movement per unit of deflection of the spring. In order that the initial tension of the spring may be varied, and thus vary the speed of the machine governed, I provide a readily accessible gearing which may be either manually or mechanically operated and which embodies a safety limit means preventing over-travel.

Referring now to the drawings for a better understanding of my invention, I show in Fig. 1, at 10, an elastic fluid turbine having an admission valve 11, controlled by my improved governing apparatus at 12. The governing apparatus at 12 is operated by variable fluid pressure developed by a centrifugal pump 13 driven by a shaft 14 of the turbine 10. Fluid for the pump, usually lubricating oil, is supplied from a reservoir 16 and is delivered to the governing apparatus 12 through a conduit 17 connected to the governing apparatus at 18.

The governing apparatus 12, Fig. 2, comprises a housing 19 which includes an operating cylinder 20. The operating cylinder 20 is provided with a bushing 21, said bushing being so fitted that it may be rotated within the cylinder 20. Within the bushing 21 is disposed an operating piston 22. The operating piston 22 is held against rotation with respect to the bushing 21 by means of a slide key, or spline connection, 23. The operating piston 22 is hollow and is provided with an upper stem portion 24 and a lower stem portion 26. The stem portions 24 and 26 extend through suitably formed heads 25 and 25′ of the cylinder 20 and form therewith an approximately fluid-tight fit. Fluid leaking past the lower stem portion 26 passes through a suitably arranged drain 28 and is returned to the reservoir 16. The lower stem portion 26 is connected to the admission valve 11 by a stem 27 so that movements of the operating piston 22 are communicated directly to the admission

valve 11. The operating piston 22 is provided with ports 29 leading from the interior thereof to its upper face and ports 31 leading from the interior thereof to its lower face.

Disposed within the operating piston 22 is a pilot valve 32. The pilot valve 32 is also hollow and is provided with an annular series of ports 33 extending through its walls, said ports 33 being adapted when in registry with port 31 of the operating piston 22, to admit fluid under pressure beneath the operating piston, forcing it upwardly. The pilot valve 32 is also provided with a reduced portion 34 which, when in registry with the lower port 31 of the operating piston 22, permits fluid to pass from beneath the operating piston 22 through port 31, the reduced portion 34 and the upper port 29. From the upper side of the operating piston 22 it is returned to the reservoir 16 through a drain 35. Between the reduced portion 34 and the port 33 of the pilot valve 32 is an annular shoulder 36 serving to separate the port and the reduced portion and also serving, when in registry with port 31, to lap said port and prevent the admission of fluid to, or exhaust of liquid from, the lower side of the operating piston 22. The pilot valve 32 is subjected, at all times, to fluid under pressure admitted at 18. Opposing the fluid pressure is a spring 37 in tension between an abutment 38 and a cap member 39 of the pilot valve 32.

The operation of the apparatus so far described is as follows: Fluid under pressure developed by the pump 13, varying with the speed of the turbine 10, is admitted at 18 and acts against the upper stem portion 24 of the operating piston 22 tending to force it downwardly and also acts against the pilot valve 32 tending to force it downwardly. Assuming that the turbine is being started and that a comparatively low pressure is being developed by the pump 13, the pilot valve 32 is in its uppermost position due to the initial tension of the spring 37. In this position port 33 of the pilot valve is in registry with port 31 of the operating piston and fluid under pressure passes beneath the operating piston 22. The area of the operating piston 22 is made greater than the area of the stem portion 24 so that with equal pressure acting in opposite directions upon the stem portion 24 and the lower face of the piston 22, the piston is held in its uppermost position. As soon as the speed of the turbine increases sufficiently for the pump 13 to develop a pressure greater than the initial tension of the spring 37, the pilot valve 32 is forced downwardly connecting the lower port 31 of the operating piston 22 with the upper port 29 through the reduced portion 34 of the pilot valve 32. Fluid from beneath the operating piston 22 then passes outwardly through the drain 35. A lesser pressure now being existent beneath the piston 22, fluid pressure acting against the upper stem portion 24, forces it downwardly until the annular shoulder 36 of the pilot valve 32 covers the port 31, cutting off the flow of fluid from beneath the piston 22. In this position the parts are in equilibrium and no further movement will take place until a change in governing pressure occurs. The downward movement of the operating piston 22, just described, imparts a closing movement to the admission valve 11 and thus throttles the supply of elastic fluid to the turbine 10. Upon a decrease in speed and a consequent decrease in governing fluid pressure, the force of the spring 37 causes the pilot valve 32 to move upwardly again admitting fluid under pressure beneath the piston 22 through ports 33 and 31, causing the operating piston 22 to move upwardly, opening wider the admission valve 11.

From the structure and operation thus far described, it will be obvious that for each movement of the pilot valve 32 there is an equivalent movement of the operating piston 22 and that the position of the operating piston 22 is determined by the position of the pilot valve 32. It will furthermore be obvious that unless some mechanism is provided for multiplying the effect of the deflection of the spring 37, the only governing movement obtainable is that movement determined by the scale of the spring 37, or deflection of the spring 37 per unit of change in governing pressure. In order that a comparatively wide governing movement may be obtained per unit of change in governing pressure and per unit of deflection of the spring 37, I provide a follow up mechanism for the spring abutment 38 which will now be described.

Disposed within the upper end of the housing 19 is a hollow screw member 41, Figs. 2 and 3. The hollow screw member 41 is provided with exterior threads 42 and interior threads 43, the exterior threads 42 being of a steeper pitch than the interior threads 43. The hollow screw member 41 is held in position by a ball bearing 44 which permits freedom of rotation but prevents axial movement of the member 41. The upper hollow stem 24 of the operating piston 22 is provided with interior threads 46 fitting the exterior threads 42 of the screw member 41. The threads 42 and 46 are of a relatively steep pitch so that upon an axial movement of the operating piston 22 the screw member 41 is caused to rotate, rotating in one direction upon downward movement, and in the opposite direction upon upward movement of the operating piston 22. The spring abutment 38 is pro-

vided with a threaded portion 47 fitting the interior threads 43 of the screw member 41. The abutment 38 is also provided with an upper stem portion 48, of square or hexagon form, fitting into a similarly shaped recess 49 provided in a cover 50 of the housing 19. The abutment 38 thus may move axially but is held against rotation. It may be seen that upon movement of the operating piston 22 and rotation of the screw member 41, because of the threaded relation between the threaded portion 47 of the abutment 38 and the screw member 41, a similar movement in the same direction is translated to the abutment 38. Inasmuch as the exterior threads 42 of the screw member 41 are of steeper pitch than the interior threads 43, the movement of the abutment 38 is at a lesser rate of movement than the movement of the operating piston 22. This difference in rate of movement is essential to the proper operation of the apparatus in that it permits the operating piston 22 and pilot valve 32 to resume an equilibrium position after changes in governing fluid pressure.

With my improved follow-up mechanism just described, assume that the turbine 10 is running under normal load with uniform speed. The pilot valve 32 is in equilibrium position with respect to the operating piston 22 that is, the annular shoulder 36 covers the lower port 31 and no fluid is passing to or from the underside of the operating piston 22. If now the speed of the turbine 10 increases, followed by an increase in governing pressure, the tension of the spring 37 is overcome and the pilot valve 32 is forced downwardly, followed by the operating piston 22 in a manner already described. As the operating piston 22 moves downwardly it causes the screw member 41 to rotate to the right as seen in Fig. 3. Rotation of the screw member 41 to the right screws the abutment 38 outwardly of the screw member 41 so that the abutment 38 moves downwardly, following the operating piston 22 thus permitting the pilot valve 32 to move downwardly further than it would have moved, had the abutment 38 been rigidly held during movement of the operating piston 22. Upon a decrease in governing fluid pressure the pilot valve 32 is pulled upwardly by the spring 37 followed by the operating piston 22. Upward movement of the operating piston 22 causes rotation of the screw member 41 toward the left in Fig. 3. Rotation of the screw member 41 to the left screws the abutment 38 inwardly of the screw member, causing upward movement of the abutment following the upward movement of the operating piston 22. It may thus be seen that each deflection of the spring 37, followed by movement of the operating piston 22, is multiplied, and that upon an increase in governing pressure the operating piston 22 continues to move until the deflection of the spring 37 is compensated for by the difference in movement of the operating piston 22 and the abutment 38.

For example, if the ratio of the pitch of the threads 42 and 43 is 8 to 7 and there is a variation in governing pressure sufficient to deflect the spring 37 one eighth of an inch, the operating piston must travel eight eighths, or one full inch, before the difference in relative position of the abutment 38 and the operating piston 22 is one eighth of an inch and equilibrium is established as heretofore explained. By varying the comparative pitch of the threads 42 and 43 the movements of the operating piston 22 translated to the spring abutment 38 may be varied to secure any desired range of governing movement per unit of change in governing pressure and deflection of the spring 37.

In order to prevent improper assembly of the apparatus and also in order to prevent the abutment 38 from being screwed out of the screw member 41 upon manual operation of the speed changer, to be described later, the abutment 38 is provided with a lower stem member 52 so arranged that it engages with the lower end of the pilot valve 32 when in its lowermost position preventing the abutment 38 from being screwed out at the lower end of the screw member 41. The upper stem 48 of the abutment 38 is extended upwardly sufficiently so that it strikes a cap 51 before the abutment 38 may be screwed out of the upper end of the screw member 41.

In order that the initial tension of the spring 37 may be changed during operation, I provide the outer periphery of the cylinder bushing 21 with gear teeth 56 which cooperate with a worm gear 57, Fig. 4, by means of which the bushing 21 may be rotated. The worm gear 57 is provided with a shaft 58 having secured thereto operating means 59 by which it may be rotated either manually or by other means. Inasmuch as the operating piston 22 is held against rotation with respect to the bushing 21 by means of the splined connection 23, it will be seen that by rotating the bushing 21 the operating piston 22 is rotated. The spring abutment 38 being held against rotation by the stem portion 48, rotating the operating piston 22 causes rotation of the screw member 41 and raises or lowers the spring abutment 38, depending upon the direction of rotation. Raising or lowering the spring abutment 38 changes the initial tension of the spring 37 and thus changes the speed of the machine governed.

The shaft 58 of the worm gear 57 is tapped and threaded at one end providing interior threads 61 into which a threaded bolt

62 fits. The threaded bolt 62 is provided with a head 63 held against rotation by a yoke 64. The yoke 64 is pivoted at 66 so that upon rotation of the shaft 58 the bolt 62 is moved inwardly or outwardly of the shaft 58 and the yoke 64 is moved about the pivot 66. This movement may be employed to automatically stop a remote control mechanism, a form of which will now be described.

Referring to Figs. 1 and 5, I show an operating means for the worm gear 57 of the speed-changing mechanism, such as a motor 71, connected to the speed-changing operating means 59 as by a belt 70. The motor 71 is provided with a split field 72 permitting reversal thereof. A reversing switch 73 is arranged on a suitable switch board so that the operator may drive the motor in either direction desired. Associated with the yoke 64 are two cut-out switches 74 and 76, switch 74 being shown in section. When the motor 71 is being operated so as to cause the yoke 64 to tilt toward the switch 74 a plunger member 77 of the switch 74 comes in contact with an adjustable contact member 78 of the yoke 64. The plunger 77 is then forced inwardly of the switch 74 breaking a circuit for driving the motor 71 in one direction at 79. In like manner the switch 76 is provided with a plunger 81 which upon movement of the yoke 64 in the direction of the switch 76 comes in contact with an adjustable contact member 83. The plunger 81 is then forced inwardly of the switch 76 and breaks a circuit 84 for operating the motor in the opposite direction. The adjustable means provided on the contacts 78 and 83 may be so positioned as to stop the speed-changing motor 71 at any desired point and thus provide a definite range wherein the speed of the turbine 10 may be adjusted.

From the foregoing it will be apparent that I have invented an improved governing apparatus embodying a variable fluid pressure actuated element and employing a spring for opposing the variable fluid pressure, wherein the resistance to the variable fluid pressure afforded by the spring is varied by movement of the spring as a whole upon each deflection thereof.

While I have shown my invention in but one form, it wil be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications, without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. In a variable fluid pressure operated governing apparatus, an element movable in response to variations in the fluid pressure, a piston controlled by the element and having movements proportional thereto, a spring associated with the element and opposing the variable fluid pressure, an abutment for the spring, and a screw motor associated with the abutment and the piston for effecting a follow-up movement thereof upon deflections of the spring.

2. In a variable fluid pressure operated governing apparatus, an element movable in response to variations in the fluid pressure, a spring associated with the element and opposing the variable fluid pressure, an abutment for the spring, and a screw motor controlled by the element for effecting a follow-up movement of the abutment upon deflections of the spring.

3. In a variable fluid pressure operated governing apparatus, an element movable in response to variations in the fluid pressure, a spring associated with the element and opposing the variable fluid pressure, an abutment for the spring, and a screw motor controlled by the element for effecting a follow-up movement of the abutment at a lesser rate than movements of the element upon deflections of the spring.

4. In a variable fluid-pressure operated governing apparatus, a piston valve actuated in one direction by the variable fluid pressure, a spring for actuating the piston valve in the opposite direction, an abutment for the spring, an operating piston controlled by the piston valve and having movements equivalent to the movements of the piston valve, and a screw motor actuated by the operating piston for effecting follow-up movements of the spring abutment during movements of the piston valve.

5. In a variable fluid-pressure operated governing apparatus, a piston valve actuated in one direction by the variable fluid pressure, a spring for actuating the piston valve in the opposite direction, an abutment for the spring, an operating piston controlled by the piston valve and following its movements, and a screw motor actuated by the operating piston for effecting follow-up movements of the spring abutment.

6. In a variable fluid-pressure operated governing apparatus, a piston valve actuated in one direction by the variable fluid pressure, a spring for actuating the piston valve in the opposite direction, an abutment for the spring, an operating piston controlled by the piston valve and following its movements, and a screw motor actuated by the operating piston for effecting follow-up movements of the spring abutment and at a lesser rate of movement than the operating piston.

7. In a variable fluid-pressure operated governing apparatus, a piston valve subjected on one side to the variable fluid pressure, and movable in response to variations

thereof, a spring associated with the piston valve for opposing the variable fluid pressure, a hollow screw member having exterior and interior threads, said hollow screw being free to rotate and held against axial movement, an abutment for the spring held against rotation and having a threaded portion fitting the interior threads of the screw member, an operating piston held against rotation controlled by the piston valve and following its movements, said operating piston having a sleeve portion with interior threads fitting the exterior threads of the screw member, whereby upon axial movement of the operating piston the screw member is rotated and the spring abutment is moved in the same direction as the operating piston.

8. In a variable fluid-pressure operated governing apparatus, a piston valve subjected on one side to the variable fluid pressure and movable in response to variations thereof, a spring associated with the piston valve for opposing the variable fluid pressure, a hollow screw member having exterior and interior threads, said hollow screw member being free to rotate and held against axial movement, an abutment for the spring held against rotation and having a threaded portion fitting the interior threads of the screw member, an operating piston held against rotation controlled by the piston valve and following its movements, said operating piston having a sleeve portion with interior threads fitting the exterior threads of the screw member, whereby upon axial movement of the operating piston the screw member is rotated and the spring abutment is moved in the same direction as the operating piston, but at a lesser rate of movement.

9. In a variable fluid-pressure operated governing apparatus, a piston valve actuated by the variable fluid pressure, a spring associated with the piston valve for opposing the variable fluid pressure, a hollow screw member having exterior and interior threads, the exterior threads being of steeper pitch than the interior threads, said hollow screw member being free to rotate and held against axial movement, an abutment for the spring having a threaded portion fitting the interior threads of the hollow screw member, said abutment being held against rotation, an operating piston held against rotation controlled by the piston valve and following its movements, said operating piston having a cylindrical portion with interior threads fitting the exterior threads of the screw member whereby upon axial movement of the operating piston the screw member is rotated and the spring abutment is moved in the same direction as the operating piston.

10. In a variable fluid-pressure operated governing apparatus, a piston valve actuated by the variable fluid pressure, a spring associated with the piston valve for opposing the variable fluid pressure, a hollow screw member having exterior and interior threads, the exterior threads being of steeper pitch than the interior threads, said hollow screw member being free to rotate and held against axial movement, an abutment for the spring having a threaded portion fitting the interior threads of the hollow screw member, said abutment being held against rotation, an operating piston controlled by the piston valve and following its movements, said operating piston having a sleeve portion with interior threads fitting the exterior threads of the screw member, and means for holding the operating piston against rotation, whereby upon axial movement of the operating piston the screw member is rotated and the spring abutment is moved in the same direction as the operating piston.

11. In a variable fluid-pressure operated governing apparatus, a piston valve actuated by the variable fluid pressure, a spring associated with the piston valve for opposing the variable fluid pressure, a hollow screw member having exterior and interior threads, the exterior threads being of steeper pitch than the interior threads, said hollow screw member being free to rotate and held against axial movement, an abutment for the spring having a threaded portion fitting the interior threads of the hollow screw member, said abutment being held against rotation, an operating piston controlled by the piston valve and following its movements, said operating piston having a sleeve portion with interior threads fitting the exterior threads of the screw member whereby upon movement of the operating piston a follow up movement of the abutment is effected, a worm gear for normally holding the operating piston against rotation, and means for operating the worm gear and rotating the operating piston thereby varying the initial tension of the spring.

12. In a variable fluid-pressure operated governing apparatus, a piston valve actuated by the variable fluid pressure, a spring associated with the piston valve for opposing the variable fluid pressure, a hollow screw member having exterior and interior threads, the exterior threads being of steeper pitch than the interior threads, said hollow screw member being free to rotate and held against axial movement, an abutment for the spring having a threaded portion fitting the interior threads of the hollow screw member, said abutment being held against rotation, an operating piston controlled by the piston valve and following its movements, said operating piston having a sleeve portion with interior threads fitting the

exterior threads of the screw member whereby upon movement of the operating piston a follow up movement of the abutment is effected, a worm gear for normally holding the operating piston against rotation, a motor for operating the worm gear and rotating the operating piston, thereby varying the initial tension of the spring, and automatic means for stopping the motor upon a predetermined movement thereof in either direction.

In testimony whereof, I have hereunto subscribed my name this tenth day of November 1924.

HENRY R. TROTTER.