

April 8, 1941.

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2,237,780

TURBINE GOVERNOR

Filed March 8, 1939

2 Sheets-Sheet 1

FIG. 1.

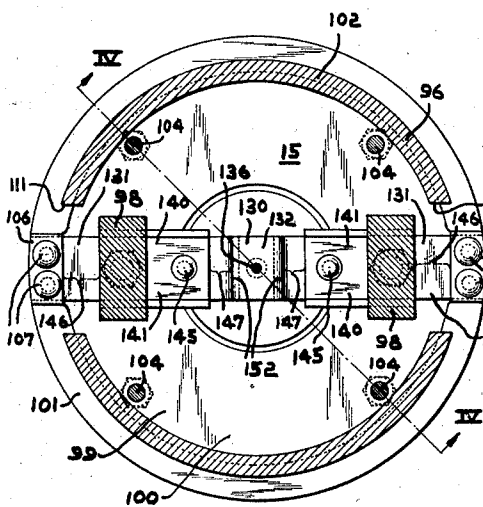
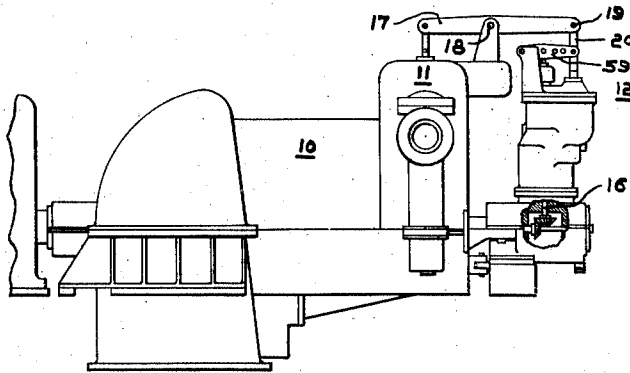


FIG. 3.

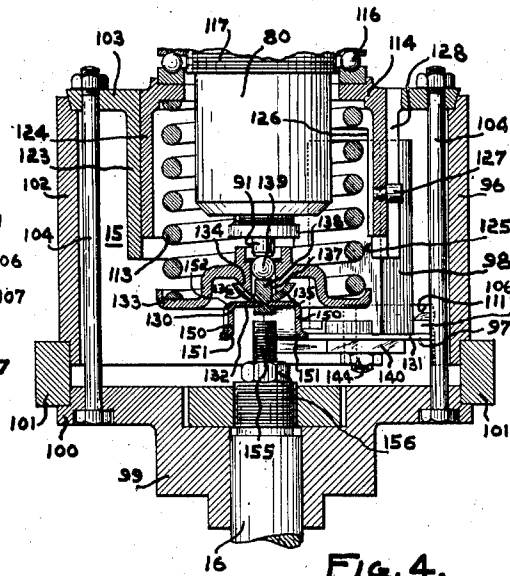


FIG. 4.

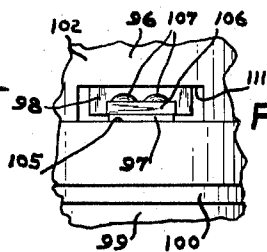


FIG. 5.

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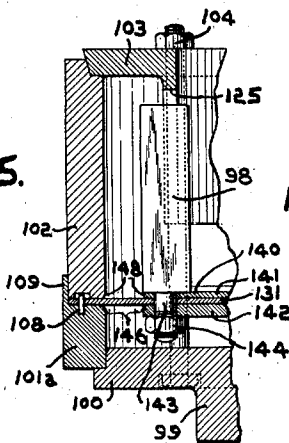


FIG. 6.

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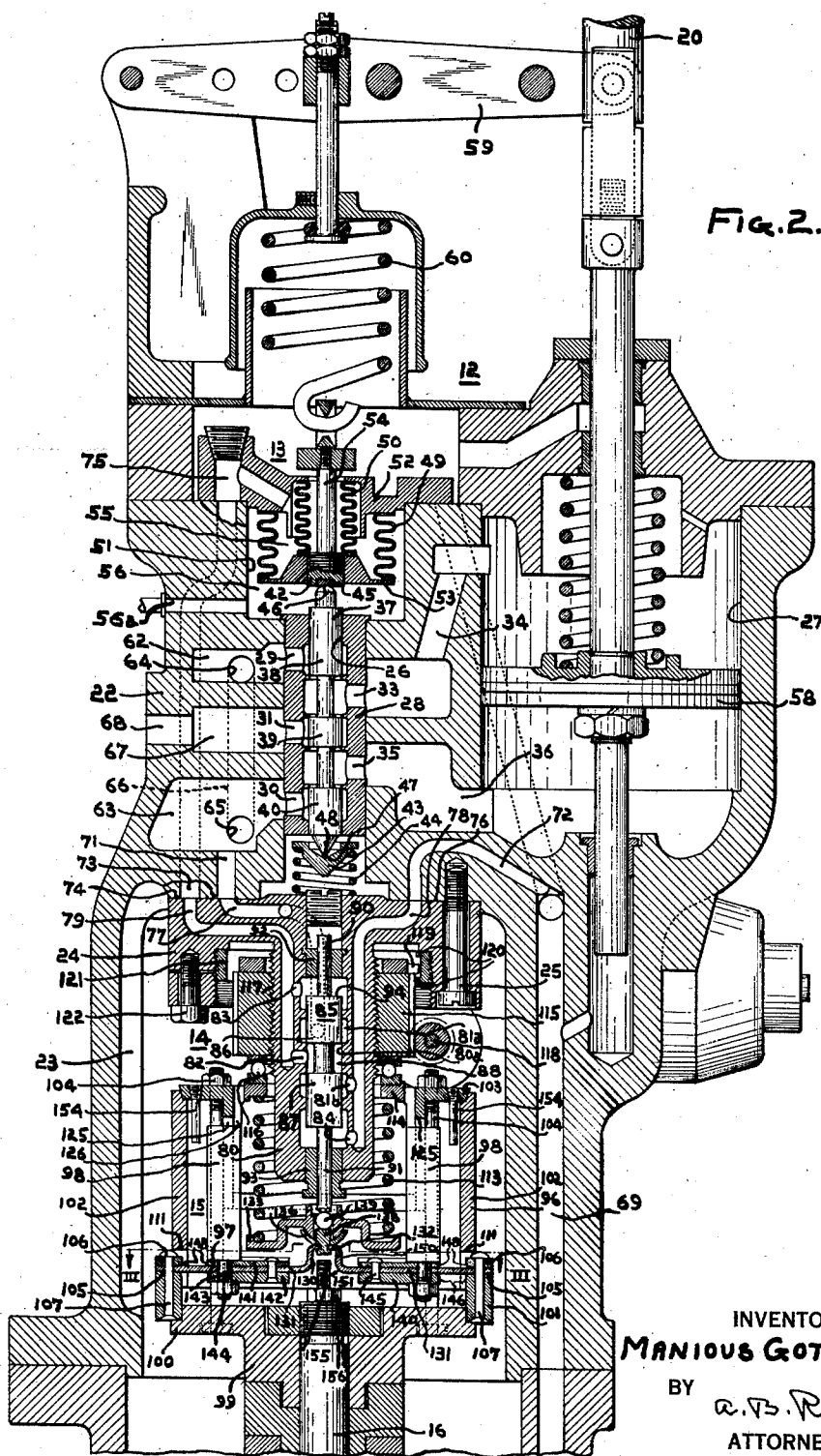
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TURBINE GOVERNOR

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2 Sheets-Sheet 2



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2,237,780

TURBINE GOVERNOR

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Application March 8, 1939, Serial No. 260,478

16 Claims. (Cl. 264—18)

My invention relates to a fly-weight governor of the force type, as distinguished from the motion type, and it has for an object to provide apparatus of this character wherein friction and looseness are avoided and low resistance to operation is secured by having the fly-weights carried by a transversely flexible member, which serves to transmit the centrifugal force thereof to suitable force-responsive controlling means for the apparatus to be governed.

A further object of my invention is to provide a governor having a leaf spring extending diametrically of its rotary driving member and carrying the fly-weights, the leaf spring functioning to transmit centrifugal force of the fly-weights to suitable force-responsive means.

A further object of my invention is to provide a centrifugal governor wherein a leaf spring is used to support the fly-weights and to transmit the centrifugal force effect thereof to a transformer, which converts force and changes therein received from the leaf spring into transformed pressure and changes in the latter.

A further object of my invention is to provide a centrifugal governor wherein the fly-weights are carried by a leaf spring which functions to transmit the centrifugal force of the fly-weights to a transformer operating to convert changes in force to changes in pressure together with a relay utilizing changes in pressure received from the transformer to secure changes in motion, the latter being utilized to control the position of a part, such as a governor valve.

A further object of my invention is to provide a governor including fly-weights, a load spring, force-responsive means, a leaf spring and thrust connections between the load spring and the leaf spring and between the latter and the force-responsive means.

A further object of my invention is to provide a governor and force-responsive controlling means wherein the governor weights are carried by a leaf spring and a thrust connection is arranged between the leaf spring and the force-responsive means.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a side elevational view of apparatus having my improved governing mechanism applied thereto;

Fig. 2 is a vertical sectional view of the relay, transformer, and governing mechanism;

Fig. 3 is a horizontal sectional view taken along the line III—III of Fig. 2;

Fig. 4 is a vertical sectional view taken along the line IV—IV of Fig. 3;

Fig. 5 is a detail view showing the connection of the leaf spring to one of the supports; and,

Fig. 6 shows a construction having a modified connection for the leaf spring ends.

The present invention relates to the general type of governor disclosed in the patent to Zelov, No. 2,101,486, dated December 7, 1937, and which is distinguishable from fly-weight governors in general in that it is essentially force governing rather than motion governing. The ordinary fly-ball governor has a motion range from no load to full load, and this motion is used directly, or by a relay, to control any desired part, such as a governor valve. On the other hand, with the force type, and due to the pressure transformer which utilizes changes in force to secure changes in pressure, the fly-weights have very little movement from no load to full load, the centrifugal force being directly impressed on the transformer so that force changes are converted into transformed pressure changes. A transformer has the advantage of providing suitably wide pressure range for a small force range in going from no load to full load. Changes in transformed pressure are converted into motion changes by a suitable relay having a pressure-responsive device acted on by transformed pressure received from the transformer. In addition to the novel relation of the governor, the transformer, and the relay, a particular feature of the present invention is the means for supporting the fly-weights and for transmitting the centrifugal force thereof to the transformer, such feature preferably comprising a transversely extending leaf spring carrying the fly-weights and serving to transmit the centrifugal force of the latter to the transformer piston. The leaf spring serves as an elastic hinge, the small amount of fly-weight motion required for operation of the transformer piston occurring with very small motion or deformation of the leaf spring distributed as flexure thereof, whereby the governor is frictionless and is without looseness or lost motion.

Referring now to the drawings more in detail, in Fig. 1, there is shown apparatus to be governed, for example, a steam turbine, at 10, having an admission or governor valve, at 11, the governor valve having its position controlled by the pressure-responsive relay, at 12, operating to convert changes in pressure into changes in position, the relay functioning in response to transformed oil pressure changes furnished to its pressure-responsive device, at 13, by the transformer, at 14, which converts force changes into liquid pressure changes, the transformer being subject to force changes of the centrifugal governor, at 15, operated by means of the shaft 16 driven by the prime mover, at 10.

Preferably, the relay, at 12, the transformer,

at 14, and the centrifugal governor, at 15, have a superposed relation, thereby providing for a simpler and more compact structure, one more economical to produce, and for a peculiarly desirable operating relation of the governor and the transformer. The governor valve 11 is positioned by means of the lever 17 fulcrumed at 18 and pivoted at 19 to the upper end of the rod 20 of the relay, at 12.

Referring now to the relay, the transformer, and the centrifugal governor, there is shown a first or body structure 22 having a governor cavity 23 within which depends a second body or structure 24 fastened in abutting relation to the first structure by screws 25.

The relay comprises a pilot valve cylinder 26 and an operating cylinder 27 formed in the structure 22, the pilot valve cylinder being preferably provided by a liner 28. The pilot valve cylinder has upper and lower pressure ports 29 and 30 and an intermediate exhaust port 31. Between the pressure port 29 and the exhaust port 31, there is an admission and exhaust port 33 communicating with the passage 34 leading to the upper end of the cylinder 27; and, between the exhaust port 31 and the lower pressure port 30, there is an admission and exhaust port 35 communicating with the passage 36 leading to the lower end of the operating cylinder. A pilot valve 37 is arranged in the cylinder 26, the pilot valve having upper, intermediate and lower lands 38, 39 and 40, respectively, for interrupting communication of the pressure and drain ports with the admission and exhaust ports as long as the pilot valve is in its neutral position.

The pilot valve 37 is held in position and moved by means preventing binding, the upper and lower ends being held between abutments 42 and 43, the lower abutment being carried by the spring 44 and the upper abutment 42 being carried by the pressure-responsive device, at 13.

The abutments cooperate with the ends of the piston valve in such manner as to prevent binding, that is, the upper abutment is free to tilt or to move laterally relatively to the upper end of the piston valve and the lower abutment may tilt angularly in various directions to suit the spring 44 without any of these motions being transmitted to the piston valve. To this end, the upper abutment 42 has a flat-faced hardened bearing block 45 engaging the convex upper end 46 of the pilot valve, and the lower abutment 43 is in the form of a cup stably supported by the spring 44 and having its conical bottom 47 providing a bearing for the lower pointed end 48 of the pilot valve. Thus, it will be seen that, if the upper abutment 42 moves downwardly, the pilot valve is also constrained to move, the spring 44 being compressed; on the other hand, if the upper abutment 42 moves upwardly, then the force of the spring 44 acting on the lower abutment 43 causes the pilot valve to follow the motion of the upper abutment with maintenance of contact with the latter.

The pressure-responsive device, at 13, includes outer and inner bellows 49 and 50 arranged in the chamber 51 formed in the body structure 22 and having a cover 52. The lower end of each bellows is connected to a bottom closure 53 forming a rigid connection with the stem 54 carrying the abutment 42 and its hardened block 45, the stem being arranged approximately in axial alignment with the pilot valve. The upper ends of the inner and outer bellows 49 and 50 are attached to the cover 52, the space between the

bellows providing a pressure chamber 55 arranged to receive transformer oil pressure in a manner to be described, and the space 56 between the outer bellows and the wall of the chamber may be used as an additional pressure chamber for controlling purposes, an inlet 56a being shown for such additional pressure.

The operating cylinder 27 has a piston 58 therein connected to the rod 20, the latter not only being connected to the lever 17 for the governor valve but also being connected to follow-up mechanism including the lever 59 and the spring 60 between the operating piston and the stem 54 of the pressure-responsive device, at 13.

In operation, if there is a change in transformed pressure, the upper abutment moves correspondingly to change the position of the pilot valve 37 thereby bringing about admission and exhaust of motive fluid through the passages 34 and 36 to change the position of the operating piston 58 and the admission valve, at 11. As the operating piston 58 moves, the force of the spring 60 changes in such a direction as to tend to restore the pilot valve 37 to neutral position, movement of the operating piston and the admission valve continuing until the change in force of the spring 60 balances the change in fluid pressure force with the pilot valve 37 restored to neutral or cut-off position.

The body or structure 22 is also preferably cored to provide various spaces and passages for fluid. It has upper and lower spaces 62 and 63 supplied with oil under high pressure by any suitable means, for example, by the ports 64 and 65 connected to the passage 66. Between the high pressure oil spaces 62 and 63, there is a drain space 67 having a drain port 68. The upper and lower high pressure fluid spaces 62 and 63 communicate with the pressure ports 29 and 30 and the drain space 67 communicates with the drain port 31. The body or structure 22 has cored passages 71, 72 and 73 extending through the abutment face 74 thereof and communicating, respectively, with the high pressure space 63, the exhaust or drain space 69, and the pressure chamber 55 of the pressure-responsive device, at 13, the upper end of the passage 73 communicating with a passage 75 formed in the cover 52 and opening into the chamber 55.

Referring now to the transformer, at 14, for converting force changes into pressure changes, the second structure 24 has an upper surface 76 abutting with the surface 74 and having passages cored therein, the passages including a high-pressure passage 77 communicating with the passage 71, a drain or exhaust passage 78 communicating with the passage 72, and a transformed oil pressure passage 79 communicating with the passage 73.

The structure 24 is formed with a barrel portion 80 providing the transformer cylinder 80a. The transformer cylinder has a high-pressure port 81a communicating with the high-pressure passage 77, a drain port 81b communicating with the drain passage 78 and an intermediate transformed oil pressure port 82. Also, the cylinder has ports 83 and 84 communicating with the upper and lower ends thereof, and with the transformed pressure passage 79 and the drain passage 78, respectively.

A piston valve 85 is arranged in the cylinder and it has spaced upper and lower lands 86 and 87, which, for a neutral position of the piston, just lap the pressure and drain ports 81a and 81b, the space between the lands and the wall

of the cylinder providing a transformed oil pressure space 88 in communication with the port 82. The transformer piston valve is guided by upper and lower stems 90 and 91 fitting bushings 92 and 93, respectively. The lower end of the stem 91 having force applied thereto in the manner to be described, and this force, together with the force of transformed pressure acting on the piston area 94 of the outer end of the land 86 remote from the governor, at 15, positions the piston valve and tends to restore the latter to neutral position. Both the transformer cylinder 80a and the piston valve are in approximate axial alignment with the relay pilot valve and with the abutment stem 54.

The centrifugal governor, at 15, includes the rotary member or shaft 16 in approximate axial alignment with the transformer piston valve 85 and with the relay pilot valve 37, the upper end of the shaft 16 being connected to a drum structure 96 carrying the transversely flexible member or leaf spring 97, which supports a pair of elongated fly-weights 98, the flexible member or leaf spring extending diametrically of the drum structure and of the shaft 16 and serving to transmit the centrifugal force of the fly-weights to the lower end of the transformer piston stem 91.

The drum or cage 96 includes a collar 99, attached to the upper end of the shaft 16 and having a flange 100, a support ring 101, a cylindrical casing 102, and a closure 103 for the upper end of the ring 102, these parts being held in superposed relation by means of bolts 104 (Fig. 4).

The ring 101 provides diametrically opposed supports 105 for opposite ends of the leaf spring 97.

As shown in Figs. 1 to 5 inclusive, the ends of the leaf spring are attached to the diametrically opposed supports 105 by means of clamping blocks 106 arranged above the leaf spring and rivets 107 extending through the ring, the leaf spring, and the blocks.

As shown in Fig. 7, instead of having the ends of the leaf spring attached to the ring by rivets, the ends of the spring are held in place by means of pins 108 carried by the ring 101a, the ring having an axial flange 109, which encompasses the cylinder 102, the lower end of the latter cooperating with the ring to grip the ends of the spring, whereby a stronger structure is provided. With the form shown in Figs. 1 to 5, inclusive, the casing or cylinder has openings 111 affording clearance for the regions of attachment for the ends of the leaf spring.

A load spring 113 is arranged in telescopic relation with respect to the depending barrel 80, the load spring being arranged within the interior space of the cylinder drum 102 and having abutment devices cooperating with the upper and lower ends thereof. The upper abutment device comprises a lower ring 114, an upper ring 115 and an intervening thrust bearing 116, the upper ring having threaded connection 117 with respect to the exterior of the barrel 80.

The upper ring 115 may be turned in any suitable manner to vary the force of the spring. As shown, the upper ring is geared to a suitable speed changer shaft 118. Preferably, the upper ring 115 is provided with a lug 119 movable between the stops 120 carried by the ring 121 having threaded connection to the structure 24, the ring being held in any desired position of ad-

justment by means of the locking device 122. Thus, it will be seen that the upper ring has a range of movement determined by the travel of the lug 119 between the stops 120 and that this range may be shifted upwardly and downwardly by raising and lowering the ring 121.

The closure 103 has a depending sleeve 123 (Fig. 4) forming a cylindrical guide for the depending cylindrical guide 124 forming a part of the lower abutment ring 114. Both the depending sleeve 123 and the guide 124 are provided with clearance openings 125 and 126 for the fly-weights 98 and the guide 124 has a key 127 fitting a slot 128 formed in the depending sleeve 123 and preventing the lower ring and its guide from turning when the upper ring is adjusted to vary the force of the load spring.

The leaf spring 97 has an intermediate bent section 130 and adjacent straight sections 131, the outer ends of the latter being attached, as already pointed out, to the diametrically opposed supports 105. The bent section 130 provides a force-transmitting portion 132, which is aligned with the shaft 16 and with the transformer piston valve 85.

A thrust connection is interposed between the lower end of the load spring 113 and the force-transmitting portion 132, such thrust connection including the abutment ring or device 133 for the lower end of the spring, the ball member 134 arranged centrally with respect thereto and depending from the lower face thereof, and the socket member 135 carried by the structure 136 attached to the force-transmitting portion 132 of the spring.

The lower abutment 133 and the ball member 134 are provided with an axial passage 137 through which extends a second thrust connection interposed between the force-transmitting portion 132 of the leaf spring and the lower end of the relay piston valve stem 91. As shown, the second thrust connection includes an abutment 138 and a ball 139 arranged between the latter and the lower end of the stem 91, the abutment 138 and the stem 91 constituting spaced abutments and the ball providing an intermediate abutment, the normal transverse opposed end faces of the spaced abutments, together with the convex contacting faces of the intermediate abutment, permitting of various movements of the structure 136 both angularly and laterally with respect to the stem 91 with maintenance of the thrust connection and without any force being transmitted to the transformer piston and tending to bind the latter. The portion of the second thrust connection extending through the passage 137 is made smaller than the latter, not only to permit of relative adjustment movements of the lower abutment 138 with respect to the upper abutment 91, but also the clearance between the second connection and the boundary of the passage provides for tilting movement or adjustment of the lower spring abutment 133 to suit the spring 113 without disturbing the second thrust connection or the leaf spring 97.

The fly-weights 98 are attached to the leaf spring straight sections 131 by means of clamps 140, each comprising plates 141 and 142 arranged at opposite sides of the straight sections, the fly-weights having tenons 143 extending through registering openings formed in the plates 141 and 142 and in the straight sections 131 and nuts 144 cooperating with the tenons to attach

the weights and to exert the desired compression of the clamp plates with the straight section. In addition to the fly-weight tenons, rivets 145 also serve to clamp the plates compressively in contact with opposite faces of the straight sections.

Due to the stiffening effect of the fly-weight clamps, the leaf spring straight sections 131 have outer portions 146 between the outer ends of the clamps 140 and the supports 105 and inner portions 147 between the inner ends of the clamps and the bent section 130 which are free to flex, the adjacent corners of the support 105, the plate 106 and the clamp plates 141 and 142 being preferably rounded as indicated at 143 to prevent corner stress concentration.

The bent section 130 is preferably U-shaped, it comprising leg portions 150, preferably arranged approximately at right angles to the straight sections, the leg portions being joined by rounded portions 151 to the sections 131 and by rounded portions 152 to the bottom or force-transmitting portion 132.

With the arrangement of a leaf spring and fly-weights shown and described, it will be apparent that the centrifugal force of the fly-weights is readily transmitted by means of the leaf spring to the force-transmitting portion 132 thereof, the portions 146 and 147 of the straight section, the leg portions 150 and the rounded portions 151 and 152 flexing to the required extent so that force may be impressed on the bottom portion 132 and transmitted from the latter to the transformer piston valve through the thrust transmitting connection. Any tendency of the fly-weights to move outwardly with increase in centrifugal force due to increase in speed and decrease in load, since the outer ends of the leaf spring 97 are fixed to the supports 105, is accompanied by a tendency to bowed deformation of the leaf spring as a whole, this necessitating elongation to the extent of bowing. The necessary elongation is readily provided by flexing of the leg and rounded portions of the bent section. As the transformer serves to convert changes in force into changes in pressure with very slight movement of the transformer piston, it will be apparent that the fly-weights 98 are required to have only slight movement.

The cover 103 of the drum construction preferably has pins 154 for limiting outward movement of the fly-weights. Also, an adjustable stop 155 is preferably carried at the upper end of the shaft 16 for limiting downward movement of the leaf spring and the abutment structure 130 under the influence of the spring 113. When the prime mover comes to a stop, the spring 113 can move the fly-weights 98 inwardly and the leaf spring 97 downwardly only to the extent of the clearance between the upper end of the stop 155 and the abutment structure 130, this clearance being suitably varied by adjustment of the stop 155, the latter preferably having threaded connection with respect to the shaft 16 and being held in adjusted position by means of the jam nut 156. Thus, the stop pins 154 limiting outward movement of the fly-weights and the stop 155 limiting inward movement thereof, assure that the range of movement of the fly-weights and of the spring may be kept within suitably narrow limits preventing overstress and so that the parts will occupy a position suitable for transmission of centrifugal force to the transformer and conversion by the latter of such force into pressure.

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

What I claim is:

1. In a governor providing fluid under pressure, a rotary member; a leaf spring extending diametrically of the rotary member, having its ends supported by the latter, and having an intermediate bent section providing a force-transmitting portion aligned with the rotary member; fly-weights carried by the leaf spring; a transformer for transforming changes in force into changes in fluid pressure; said transformer including a valve member in axial alignment with the rotary member and a housing for the valve member; a load spring; and thrust connections between the load spring and said leaf spring force-transmitting portion and between the latter and the transformer valve member.

2. In a governor providing fluid under pressure, a rotary member; a leaf spring extending diametrically of the rotary member, having its ends attached to the latter, and having an intermediate section providing a force-transmitting portion aligned with the rotary member; a pair of fly-weights carried by the leaf spring; a transformer for transforming changes in force into changes in fluid pressure; said transformer including a valve member in axial alignment with the rotary member and a housing for the valve member; a load spring telescopically arranged with respect to the housing; an abutment for one end of the load spring and carried by the housing; and thrust connections between the other end of the load spring and said leaf spring force-transmitting portion and between the latter and the transformer valve member.

3. In a governor providing fluid under pressure, a rotary member; a leaf spring extending diametrically of the rotary member, having its ends attached to the latter, and having an intermediate section providing a force-transmitting portion aligned with the rotary member; a pair of fly-weights carried by the leaf spring; a transformer for transforming changes in force into changes in fluid pressure and including a valve member in axial alignment with the rotary member and a housing for the valve member; a load spring telescopically arranged with respect to the housing; an abutment for one end of the load spring and carried by the housing; a first thrust connection between the other end of the load spring and said leaf spring force-transmitting portion and including ball-and-socket members, the portion of said connection adjacent to the load spring and its ball-and-socket member having an axial passage; and a second thrust connection between said leaf spring force-transmitting portion and said transformer valve member and extending through said passage.

4. In a governor providing fluid under pressure, a rotary driving member; a hollow drum axially aligned with and carried by the driving member; a leaf spring extending diametrically of the drum, having its ends attached to the latter, and having an intermediate section providing a force-transmitting portion aligned with the axis of the drum and the rotary member; a pair of fly-weights within the drum, supported by the leaf spring at one side of the latter, and extending substantial-

ly parallel to the drum axis; a transformer for transforming changes in force into changes in fluid pressure and including a valve member in axial alignment with the axis of the drum and of the rotary member and extending within the interior space of the drum and a housing for the valve member; a load spring telescopically arranged with respect to the housing and located within the interior space of said drum; a thrust abutment for one end of the load spring and carried by the housing; and thrust connections between the other end of the load spring and said leaf spring force-transmitting portion and between the latter and the transformer valve member.

5. In combination, apparatus, controlling means for the apparatus, and a governor for the controlling means: said governor including a rotary member; fly-weights; a member carrying the fly-weights, supported from the rotary member, and having a portion for transmitting to the controlling means forces imparted thereto by the fly-weights axially of the rotary member; a load spring; a first thrust connection between the load spring and said force-transmitting portion and including ball-and-socket members, the portion of said connection adjacent to the spring and its ball-and-socket member having an axial passage; and a second thrust connection between said force-transmitting portion and said controlling means and extending through said passage.

6. In combination, apparatus, controlling means for the apparatus, and a governor for the controlling means: said governor including a rotary member; flyweights; an elongated member supported by the rotary member, extending diametrically of the rotary member and capable of transverse movement in a plane which is axial of the latter, and having a portion axially aligned with the rotary member for transmitting to said controlling means forces imparted thereto by the fly-weights; a load spring; a support for one end of the load spring and which is adjustable for varying the force of the latter; means for adjusting said support; a first thrust connection between the other end of the load spring and said force-transmitting portion and including ball-and-socket members, the portion of said connection adjacent to the load spring and its ball-and-socket member having a passage extending therethrough and in approximate alignment with the axis of the rotary member; and a second thrust connection between said force-transmitting portion and said controlling means and extending through said passage.

7. In combination, apparatus, controlling means for the apparatus, and a governor for the controlling means: said governor including a rotary member; fly-weights; an elongated member supported by the rotary member, extending diametrically of the rotary member and capable of movement in a plane which is axial of the latter, and having a portion aligned with the rotary member for transmitting to the controlling means forces imparted thereto by the fly-weights; a load spring; a support for one end of the load spring and which is adjustable for varying the force of the latter; means for adjusting said support; a first thrust connection between the other end of the load spring and said force-transmitting portion and including ball-and-socket members, the portion of said connection adjacent to the load spring and its ball-and-socket member having a passage extending therethrough and in approximate alignment with the axis of the rotary

member; and a second thrust connection between said force-transmitting portion and said controlling means and extending through said passage; said second thrust connection including spaced abutments carried by said force-transmitting portion and by said controlling means and an intermediate abutment having convex faces contacting therewith; said abutments extending in a direction which is axial of the rotary member, the spaced abutments having faces which are normal to the rotary member axis, and the intermediate abutment having convex faces engaging the faces of the spaced abutments; the portion of said second thrust connection arranged in the passage being of smaller cross-sectional area than the latter and the intermediate abutment being held in place by the boundary wall of said passage and by the spaced abutments.

8. In combination, apparatus to be governed, force-responsive controlling means for the apparatus and including a force-receiving element, and a governor for developing and applying force to the force-receiving element; said governor including a rotary member axially aligned with said element, a pair of diametrically-opposed and spaced supports carried by the rotary member, a leaf spring extending between the supports and having its ends attached to the latter, said leaf spring having an intermediate force-transmitting portion axially aligned with said rotary member and said element and cooperating with the latter, and a pair of fly-weights carried by said leaf spring between the supports and the force-transmitting portion and having their centers of gravity in an axial plane of the rotary member and spaced from the side of the leaf spring facing said element.

9. In combination, apparatus to be governed, force-responsive controlling means for the apparatus and including a force-receiving element capable of rectilinear movement, and a governor for developing and applying force to the force-receiving elements; said governor including a rotary member axially aligned with said element, a pair of diametrically-opposed and spaced supports carried by the rotary member, an elongated member extending between the supports and having its ends attached to the latter, said elongated member being deflectable transversely between the supports in the direction of an axial plane of the rotary member and having a force-transmitting portion aligned with the rotary member and with said element, thrust means between said portion and said element, a pair of fly-weights carried by the elongated member between said supports and said force-transmitting portion and having their centers of gravity in an axial plane of the rotary member and spaced laterally from the side of the elongated member facing said element, and a load spring for exerting force on the elongated member in opposition to the centrifugal force of the fly-weights.

10. In combination, apparatus to be governed, force-responsive means for controlling the apparatus and including a force-receiving element, and a governor for developing and for applying force to the force-receiving element; said governor including a rotary member, a pair of diametrically-opposed and spaced supports carried by the rotary member, a leaf spring extending between the supports and having its ends attached to the latter, said leaf spring having an intermediate bent section providing a force-transmitting portion axially aligned with said rotary member and said element and cooperat-

ing with the latter, and a pair of fly-weights carried by portions of the spring between the bent section and the supports and having their centers of gravity in an axial plane of the rotary member and spaced from the side of the spring facing said element.

11. In combination, apparatus to be governed, force-responsive controlling means for the apparatus and including a force-receiving element capable of rectilinear movement, and a governor for developing and applying force to said force-receiving element; said governor including a rotary member in alignment with the path of movement of said element, a pair of diametrically-opposed and spaced supports carried by the rotary member, a leaf spring extending between the supports and having its ends attached to the latter, said leaf spring having an intermediate bent section providing a force-transmitting portion axially aligned with said rotary member and said element and extending toward said element, thrust means between said portion and said element, and a pair of fly-weights carried by portions of the spring between the bent section and the supports and having their centers of gravity in an axial plane of the rotary member and spaced from the side of the spring facing toward said element.

12. In combination, apparatus to be governed, force-responsive controlling means for the apparatus and including a movable force-receiving element, and a governor for developing and applying force to the force-receiving element; said governor including a rotary member, a pair of diametrically-opposed and spaced supports carried by the rotary member, an elongated and transversely flexible spring extending between the supports and having its ends attached to the latter, said spring having an intermediate U-shaped section extending toward said element with the bottom of the U providing a force-transmitting portion axially aligned with said rotary member and said element, thrust means between said portion and the element, and a pair of fly-weights carried by the spring between the U-shaped section and the supports and having their centers of gravity in an axial plane of the rotary member and spaced from the side of the spring facing toward said element.

13. In combination, apparatus to be governed, force-responsive controlling means for the apparatus and including a movable force-receiving element, and a governor for developing and applying force to said element; said governor including a rotary member in alignment with the path of movement of said element, a pair of diametrically-opposed and spaced supports carried by the rotary member, a leaf spring having its ends attached to the supports and extending between the latter, said leaf spring having an intermediate U-shaped section extending toward said element, a pair of fly-weights having their centers of gravity in an axial plane of the rotary member and disposed at the side of the spring facing toward said element, and clamps for attaching the fly-weights to said leaf spring between the supports and the U-shaped section thereof, said clamps extending longitudinally of the leaf spring and having the ends thereof spaced from the supports and from the U-shaped section to provide leaf spring flexing portions.

14. In combination, apparatus to be governed, force-responsive controlling means for the apparatus and including a movable force-receiving

element, and a governor for developing and applying force to said element; said governor including a rotary member, a leaf spring, means for connecting the ends of said spring to the rotary member so that it extends diametrically of the latter, said connecting means including elements having opposed surfaces in the plane of rotation of the rotary member and with the end portions of the spring arranged therebetween, said spring having an intermediate bent section extending from adjacent sections toward said element and cooperating with the latter, a pair of fly-weights having their centers of gravity disposed at the side of the spring facing toward said element, and means for attaching said fly-weights to said adjacent sections including clamping plates arranged at either side and extending longitudinally thereof so as to leave flexing portions of the adjacent sections between the outer ends of the weight clamps and the connecting means for the spring ends and between the inner ends of the weight clamps and the bent sections, said connecting means and the clamps having rounded corners adjacent to ends of said flexing portions.

15. In combination, apparatus to be governed, force-responsive controlling means including a movable force-receiving element, and a governor for developing and applying force to said element; said governor including a rotary member aligned with said element, diametrically-opposed supports carried by the rotary member, a leaf spring having its ends attached to said supports and having an intermediate bent section extending laterally from the adjacent sections toward said element, said bent section including leg portions joined at one end by curved portions of small radius to said adjacent sections and joined at the other end by curved portions of short radius to an intermediate portion, said leg portions extending substantially at right angles to said adjacent sections and to said intermediate portion and said intermediate portion being aligned with the rotary member and with said element, a thrust connection between said intermediate portion and said element, and fly-weights carried by said adjacent sections, the centers of gravity of said fly-weights being spaced from the side of said adjacent sections facing toward said element.

16. In combination, apparatus to be governed, force-responsive controlling means for the apparatus including a force-receiving element which is movable rectilinearly, and a governor for developing and applying force to said element; said governor including a rotary member aligned with said element, a leaf spring having its ends attached to the rotary member and extending diametrically thereof, said leaf spring including an intermediate bent section and adjacent straight sections and the intermediate section including leg portions extending laterally from the straight sections and joined, at one end, to said straight sections and, at the other end, to an intermediate portion which is aligned with said element and with the rotary member, a thrust connection between said intermediate portion and said element, and a pair of fly-weights carried by said straight sections with their centers of gravity spaced laterally therefrom in the direction of said element and in a plane which is axial of the rotary member.