April 19, 1949. A. F. SCHWENDNER 2,467,445

GOVERNOR APPARATUS

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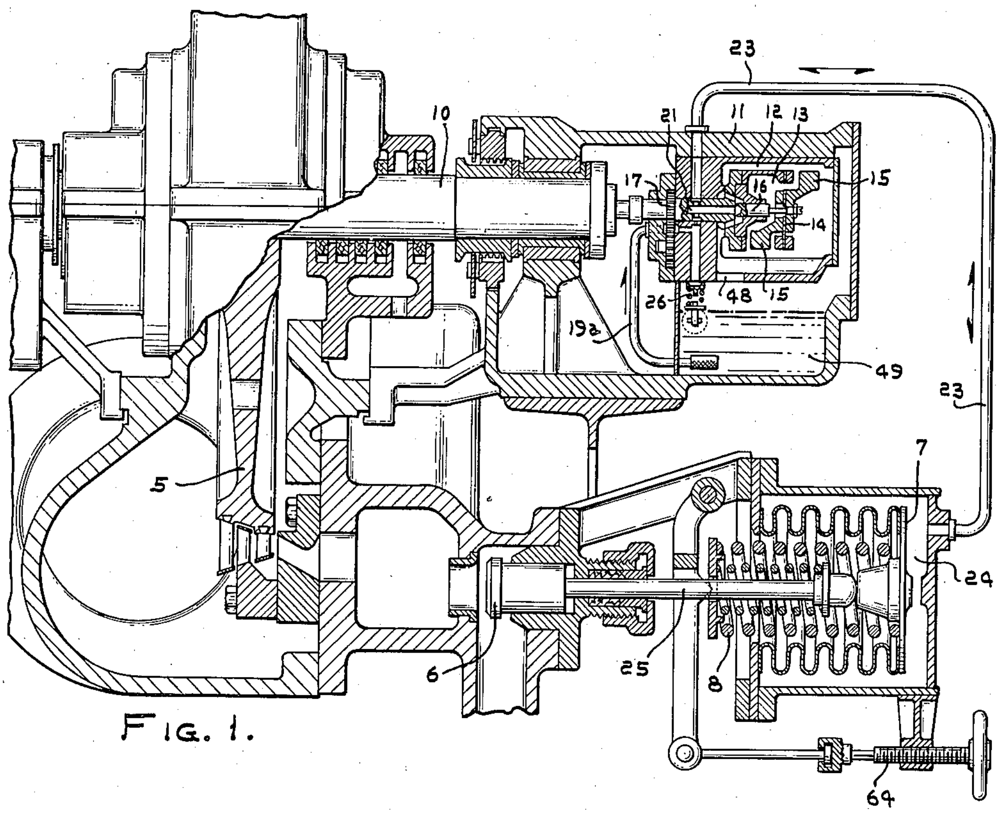

FIG. 1.

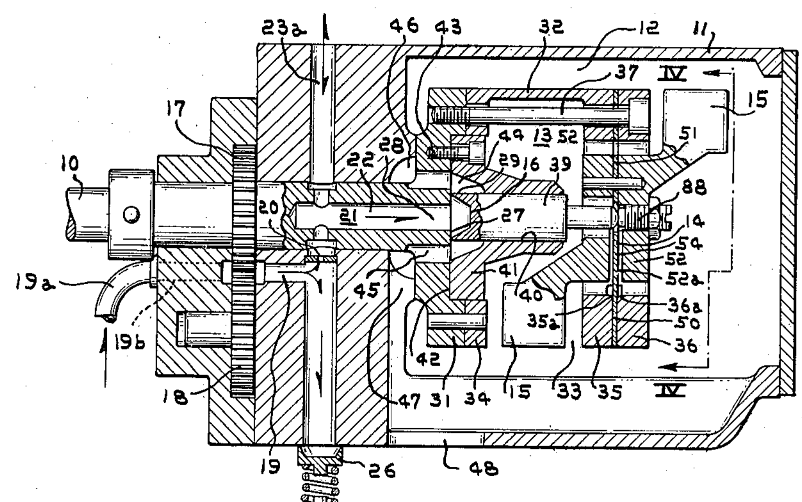

FIG. 2.

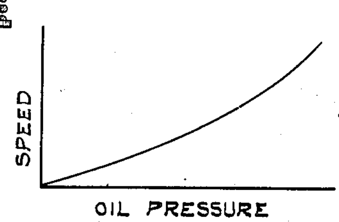

FIG. 3.

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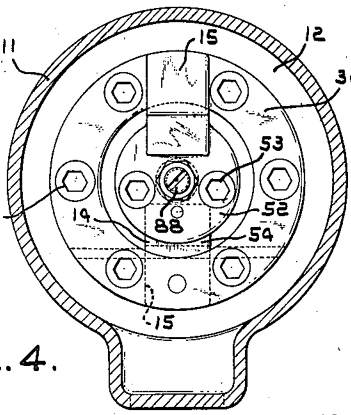

FIG. 4.

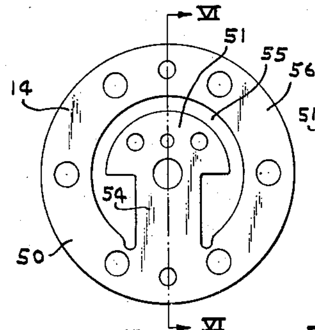

FIG. 5.

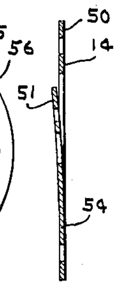

FIG. 6.

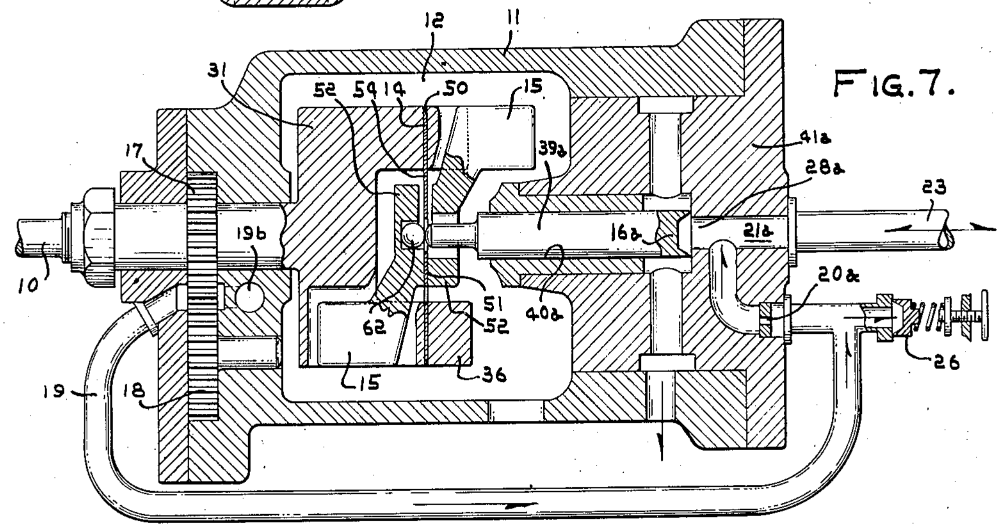

FIG. 7.

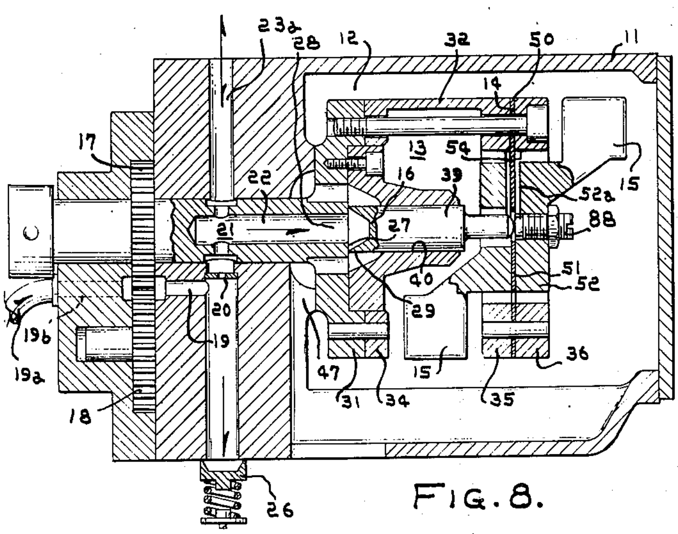

FIG. 8.

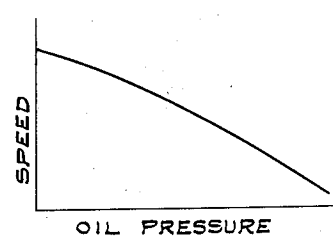

FIG. 9.

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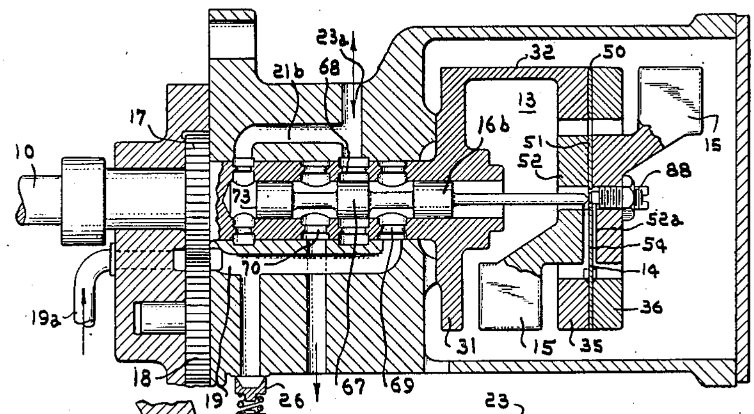

FIG. 10.

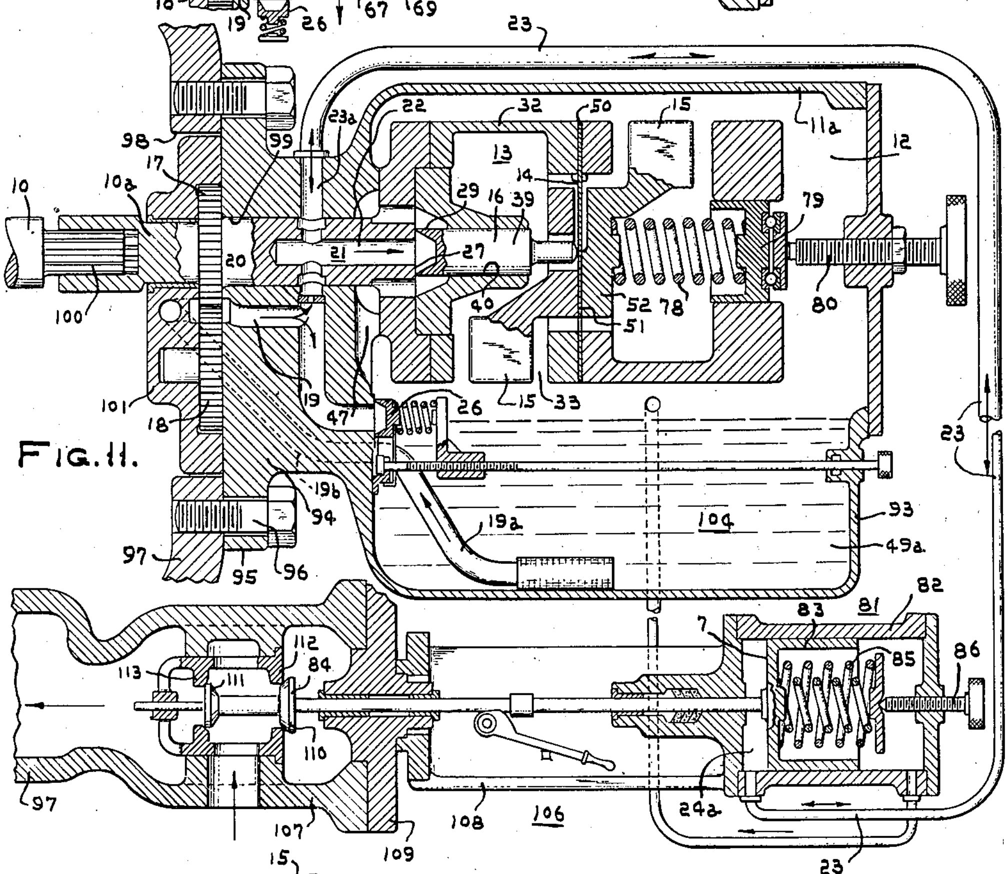

FIG. 11.

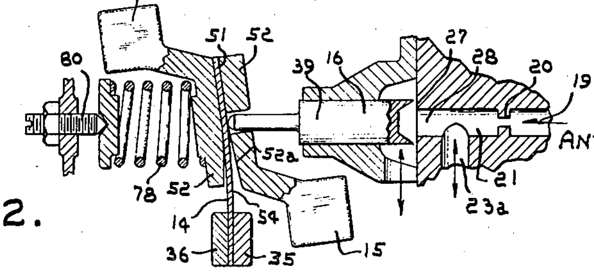

FIG. 12.

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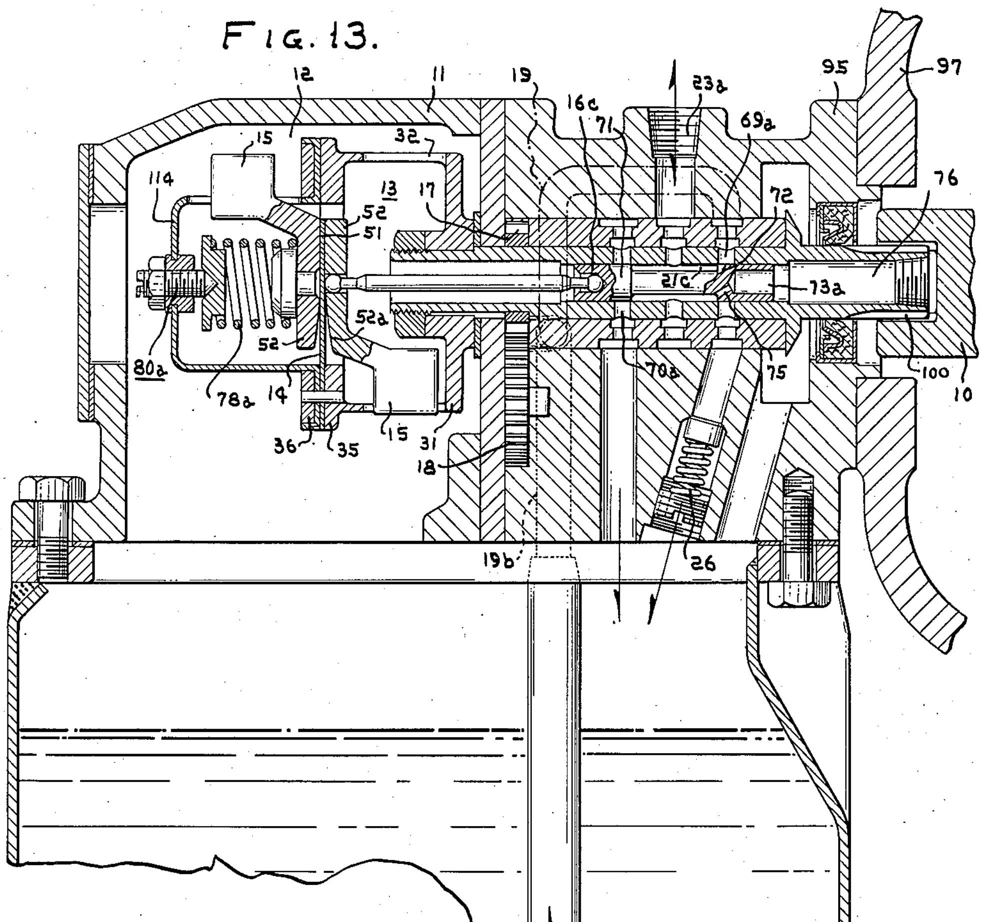
FIG. 13.



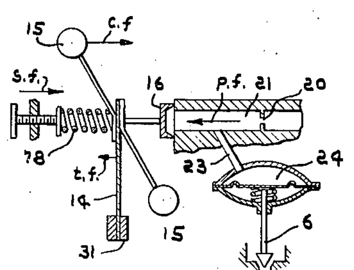


FIG. 14.

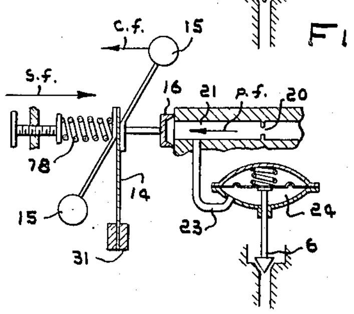


FIG. 15.

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UNITED STATES PATENT OFFICE

2,467,445

GOVERNOR APPARATUS

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Application December 16, 1944, Serial No. 568,436

7 Claims. (Cl. 264—14)

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The invention relates to a governor of the pressure transformer type, and it has for an object to provide apparatus of this character including a flyweight aggregate comprising flyweights and a leaf spring with the centrifugal force of the flyweights opposing force of the spring to develop a couple for applying force to the valve member of the transformer and which force cooperates with force applied to the latter due to transformed or liquid pressure in order to vary the transformed or governing liquid pressure dependent upon speed.

A further object of the invention is to provide apparatus of the above character which is adjustable to provide a desired range of governing speeds.

Another object of the invention is to provide a centrifugal governor including flyweights connected to a rotary driving member by a leaf spring, with the spring extending transversely of the axis of the driving member and the weights arranged to deflect the spring laterally under the influence of centrifugal force.

These and other objects are effected by the 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 view showing a turbine partly in section with the improved governor applied thereto and arranged to provide transformed or governing pressures which increase as the turbine speed increases;

Fig. 2 is an enlarged sectional view of the governor of Fig. 1;

Fig. 3 is a diagram pertaining to Fig. 1;

Fig. 4 is a sectional view taken along the line IV—IV of Fig. 2;

Fig. 5 is a detail view of the flyweight leaf spring;

Fig. 6 is a sectional view taken on the line VI—VI of Fig. 5;

Fig. 7 shows a modified form of the apparatus shown in Fig. 1;

Figs. 8 and 9 are views similar to Figs. 2 and 3, but showing an arrangement wherein the governing or transformed pressure decreases as the speed decreases;

Fig. 10 is a sectional view showing a modified form of the transformer;

Fig. 11 is a view generally similar to Fig. 7, but showing the addition of means for adjusting the speed range;

Fig. 12 is a diagrammatic view illustrative of an operation involved;

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Fig. 13 is a sectional view similar to Fig. 11, but showing modified features; and

Figs. 14 and 15 are diagrammatic views illustrative of principles involved with the direct (Figs. 1, 2 and 3) and inverse (Figs. 8 and 9) forms of the governor.

In Fig. 1 of the drawings, there is shown an elastic fluid turbine **5** having a motive fluid admission valve **6** forming a part of a movable component having a piston or pressure area **7** to which liquid under governing pressure is applied against the force of the spring **8**.

The turbine includes a rotary member or shaft **10** extending into a casing structure **11** providing a chamber **12**. Within the chamber, the drive shaft is provided with a composite body or head structure, at **13**, carrying the leaf spring **14**, the flyweights **15** attached to opposite sides of the leaf spring, and the transformer valve or relay member **16** (Figs. 1, 2, 8, 11 and 12), **16***a* (Fig. 7), or **16***b* and **16***c* (Figs. 10 and 13) by means of which the transformed or governing liquid pressure is changed.

As shown, the casing structure is formed to accommodate the gear pump, including the gear **17** connected to the drive shaft **10** and the idler gear **18** meshing therewith. The outlet passage **19** of the pump is arranged to discharge oil through the orifice **20** to the governing or transformed pressure space, at **21**, the latter preferably including, as shown in Figs. 1, 2, 8 and 11, the axial bore **22** formed in the drive shaft, the passage of the servo-motor supply conduit **23**, and the pressure space **24** of the pressure-responsive means having a movable component **25** operating the steam admission valve **6**. An adjustably loaded relief valve **26** limits the pressure in the pump discharge passage **19**.

The drive shaft **10** has one end providing a seat **27** encompassing the discharge end or port portion **28** of the bore **22**, and with which the rim **29** of the cup valve **16** cooperates to provide an annular orifice controlling the pressure of oil in the transformed or governing pressure space. A very small movement of the transformer or cup valve toward and away from the seat suffices to provide an annular orifice flow area range for governing pressure variation over a suitable range.

The body or head structure, at **13**, includes the flange **31** connected to the drive shaft, a spacing member **32** providing clearance space **33** for one of the rotating flyweights **15**, the spacing member having end ring portions **34** and **35**, and a ring **36**. The end ring portion **34** is connected by screws **37** to the flange **31** and the ring **36** is attached to the end ring portion **35** to clamp the leaf spring **14** to hold the latter in position relative to the head structure.

The transformer cup valve **16** is preferably carried by a plunger **39** arranged coaxially with the drive shaft **10** and guided by the bore **40** formed in the part **41** positioned by the counterbore **42** formed in the flange **31**, so that the bore **40** is in axial alignment with the drive shaft. A screw **43** detachably connects the part **41** to the flange. With the guide part **41** and the plunger carried by the flange **31**, it will be apparent that these elements rotate with the drive shaft which is the preferred construction, as shown in Figs. 1, 2, 8 and 11.

Oil escaping through the annular orifice provided by the cup valve rim **29** and the seat **28** enters the annular space **44** and flows from the latter through the ports **45** formed in the flange **31** to the annular chamber **46** which discharges through the passage **47** to the interior of the chamber **12** whose bottom is connected by a drain opening passage **48** to the sump **49** supplying the pump suction pipe **19***a*.

The leaf spring **14** includes outer and inner attachment portions **50** and **51** joined by a flexible portion **54**. The outer attachment portion is connected to the drive shaft so that the leaf spring extends substantially in a rotational plane of the latter and intersects the axis of rotation thereof. The outer attachment portion **50** is preferably secured to the drive shaft by being clamped between the ring portion **35** and the ring **36**.

The flyweights **15** are disposed at opposite sides of the inner attachment portion **51** of the leaf spring and they are preferably provided with feet **52** connected by screws **53** to clamp the leaf spring therebetween. The intermediate portion **54** of the leaf spring is free to flex to provide for movement of the spring and weight aggregate toward or away from the transformer valve **16**, **16***a*, or **16***b*. A maximum length of intermediate spring portion **54** for bending is provided by the clearance spaces **52***a* of the feet and the rounded portions **35***a* and **36***a* of the ring portion and ring for anchoring the outer end of the spring, whereby the small amount of total bending is distributed over a substantial length and excessive bending or stresses at any point are avoided.

The flyweights **15** are not only located at opposite sides of the leaf spring but they are arranged to have their centers of gravity spaced from opposite faces of the spring and at diametrically opposite sides of the drive shaft with the center of gravity of one of the weights at the same side of the drive shaft axis as the flexible spring portion **54**, whereby the weights are in statically balanced relation with respect to the drive shaft and are capable of developing a couple acting on the leaf spring to apply force to the valve member. More particularly, the centers of gravity of the weights are in an axial plane of the drive shaft which bisects the flexible portion **54** in the direction of its length, that is, in a plane which is the plane of symmetry of the leaf spring. As the weights are connected together as a unitary structure by the means connecting them to the leaf spring, the centrifugal force of one weight balances that of the other except for the centrifugal couple effective to apply force to the relay.

By way of example, the leaf spring is shown as formed from a disc element which is cut out arcuately, at **55**, as shown in Fig. 5, to provide an outer ring portion **56** joined by the flexible portion **54** to the inner portion **51**, and the annular portion is clamped in place between the ring portion and the ring, as aforesaid.

Increase in force applied to the plunger and the cup valve, due to the couple applied to the spring on account of centrifugal force of the weights overcoming the force of the spring, is opposed by increasing liquid pressure force acting on the valve member **16**, or increase in the couple due to centrifugal force may be accompanied by decrease in governing or transformed liquid pressure. In Figs. 1, 2, 7, 10 and 13, the couple, due to centrifugal force of the flyweights, tends to deflect the leaf spring toward the transformer to increase the transformed or governing liquid pressure. On the other hand, with the arrangement shown in Figs. 8 and 11, where an increase in speed is accompanied by a decrease in transformed or governing pressure, the effect of an increase in the couple due to centrifugal force of the flyweights acts in a direction to permit the valve member to move outwardly under the influence of force of liquid pressure applied thereto to lower the transformed or governing pressure.

While the cup valve relay plunger **39** is preferably carried by and is rotatable with the drive shaft, as shown in Figs. 1, 2, 8 and 11, it may be carried by the stationary structure **11** so that the drive shaft is rotatable relative thereto, as shown in Fig. 7. In the latter view, the casing **11** has a stationary head **41***a* providing a cylindrical guide **40***a* for the plunger **39***a* provided with the cup valve **16***a* cooperating with the escape port **28***a* of the governing liquid pressure space, at **21***a*, such space being supplied with liquid through an orifice **20***a* from a gear pump, as heretofore described. A thrust-transmitting ball **62** is preferably arranged between the spring and weight aggregate and the end of the plunger remote from the cup valve.

While the governing arrangements hereinbefore described are of the constant speed type, the speed may be adjusted over a suitable percentage by adjustment of the load spring **8** for the movable component **25** of the pressure-responsive means of Fig. 1, manually-operable mechanism **64** being shown for making this adjustment.

In Figs. 10 and 13, there are shown piston relay type transformer valves **16***b* and **16***c* which operate to achieve the purposes of the cup valve already described. The relay valve **16***b* of Fig. 10 has a piston or land portion **67** which just laps the transformed or governing pressure port **68**. The slightest movement of the valve member from the lapped position in one direction places the high-pressure port **69** in communication with the transformed pressure port **68** to increase the transformed pressure, and, in the other direction, to place the transformed pressure port in communication with the exhaust port **70** to reduce the transformed or governing pressure. While the operating principle of Fig. 14 is the same, it differs in structural detail, the relay piston valve **16***c* having spaced lands **71** and **72** whose inner edges just lap the pressure and exhaust ports **69***a* and **70***a*.

The relay valve **16***b* or **16***c* has a piston face **73** or **73***a* at one end, presenting an area to the transformed or governing liquid pressure in the space, at **21***b* or at **21***c*, so that the force due to such pressure is applied to the relay and tending to move the latter to place the transformed pressure space in communication with the exhaust port **70** or **70***a* to lower the transformed or governing pressure. Thus, it will be seen that change in force applied to the relay and due to the couple of the flyweights is accompanied by change in transformed or liquid pressure force applied to the relay in opposed relation, an increase in the couple of the flyweights due to centrifugal force and in consequence of an increase in speed and tending to move the relay in a direction to increase the transformed pressure is met by an opposing force tending to move the relay in the opposite direction. On the other hand, a decrease in the couple of the flyweights, due to a decrease in speed and consequent decrease in the force applied to the relay, results in the transformed liquid pressure force acting on the latter moving the relay in a direction to reduce the transformed or governing pressure.

Fig. 13 also differs over Fig. 10 in the way in which liquid from the transformed pressure space is applied to the relay piston valve to exert force thereon in opposition to centrifugal force. The transformed pressure space, at 21*c*, between the lands 71 and 72 is connected by a passage 75 extending through the land 72 to the equalizing space 76 to which the piston valve pressure area 73*a* is exposed. The passage 75 preferably has a sufficiently small flow area to function as an orifice to introduce a time element to provide for stability.

In Fig. 11 the leaf spring aggregate has a load spring 78 associated therewith and providing for speed range adjustment of the governor, the spring 78 having a follower 79 which is adjustable in opposite directions by means of the hand-controlled screw 80 carried by the casing structure 11*a*. The transformed governing pressure is supplied to a pressure-responsive device, at 81, including an operating cylinder 82 with an operating piston 83 therein, the transformed pressure acting on the piston 83 so as to move the admission valve 84 connected thereto in an opening direction, such movement being opposed by the spring 85 acting on the piston 83 in the opposite direction. The spring 85 is adjustable by means of the hand-controlled screw 86 to provide for a suitable percentage of speed range adjustment, for example, for a twenty per cent adjustment of speed range. The considerable amount of centrifugal force change acting on the flyweights 15 in case of wide speed range requires, for governing over a wide speed range, that change in centrifugal force shall be balanced by spring compression afforded by the spring 78 adjusted by the screw 80. As a change in spring force is represented by a change in transformed pressure applied to the pressure area 7 of the piston 83 and to the area presented by the relay cup valve, such change in force is accompanied by change in force acting on the piston area 7 in the ratio of the cup valve and piston areas.

To facilitate accurate relative positioning of the relay and the spring and weight assembly, the latter is preferably provided with a threaded abutment 88 carried by the assembly and which is adjustable to secure the desired relative positioning.

The improved governor is susceptible of being dealth with as a unit apart from the apparatus in connection with which it is used, thereby facilitating manufacture, servicing, and replacement. To this end, as shown in Fig. 11, the casing 11*a* has a depending portion 93 providing the sump 49*a*; and, at its inboard end, the casing is joined to a body 94 having a flange 95 connected by screws 96 to the machine casing 97 so as to

cover the opening 98 formed in the latter. The body is formed with a cylindrical bearing opening 99 for the stub shaft 10*a* connected by the spline coupling 100 to the turbine or machine shaft 10. A housing member 101 is attached to the inner end of the body 94 to provide a chamber for the gear pump including the gears 17 and 18. The stub shaft 10*a* is formed with the axial bore 22, as heretofore described, the bore forming a part of the transformed pressure space, at 21, and being provided, at its outer end, with an escape port with which the cup valve 16 cooperates. The body and the housing are formed with all necessary passages, including the suction and discharge passages 19*b* and 19 for the pump, the passage 19 being provided with the orifice 20 for supplying liquid to the transformed pressure space as well as to the load relief valve 26 and with the passage 23*a* connected by the pipe 23 to the displacement chamber 24*a* of the servomotor apparatus, at 81.

From the structure just described, it will be apparent that the casing 11*a*, the governing mechanism therein, the body 94, the gear pump, and the operating stub shaft 10*a* constitute a unit assembly, at 104, which may be handled as a unit, it being merely necessary to connect and disconnect the piping and attach and detach the body 94 to the casing 97 incident to assembly and removal thereof with respect to the latter, the spline coupling 100 permitting of connection and disconnection of the sub shaft 10*a* with respect to the turbine or machine shaft 10.

Furthermore, as shown in Fig. 11, the servomotor apparatus, at 81, and the valve 84 are arranged as an assembly capable of being handled as a unit, at 106, for attachment and detachment with respect to the valve housing 107 connected to the machine or turbine casing 97 in any suitable conventional manner (not shown). To this end, a structural member 108 has its inner end attached to the cover 109 of the valve housing and has its other end attached to the servo-motor cylinder 82. The unit, at 106, may be assembled with respect to the machine or turbine or removed therefrom by attachment of the flange 109 to the valve housing, the balanced valve 84 being readily removable with the unit. As shown, the valve includes spaced valve elements 110 and 111 cooperating with valve seats formed on the flanges 112 and 113 of the valve cage. The opening formed in the flange 112 to provide the seat for the valve element 110 is of a diameter not less than the valve element 111 so that the latter may be moved through the opening incident to removal and assembly of the unit.

Fig. 13, like Fig. 11, is provided with a load spring 78*a*; however, instead of the adjusting screw 80 being carried by the casing 11*a*, as in Fig. 11, the adjusting screw 80*a* is carried by a support 114 attached to the rotating governor head, at 13.

As shown in Figs. 6 and 12, the leaf spring 14 is preferably prebent with the result that it offers increasing tension force opposing straightening. With the direct form of governor, where increase in centrifugal force is accompanied by increase in transformed or governing pressure, no pressure exists in the transformed pressure space until the speed increases to enable the centrifugal force of the flyweights to overcome the tension of the leaf spring, the latter attaining a position such that it falls substantially within a rotational plane of the drive shaft, at the governing speed. The governing speed may be lowered by supplementing the centrifugal force of the flyweights with force due to the spring 78, the greater the force of the spring 78 acting in a direction to increase the transformed pressure, the less the centrifugal force required to move the cup valve in a direction to increase the pressure.

On the other hand, with the inverse arrangement, a straight spring, or one which is not preset, as by bending, is used, the tension force of such spring being zero in its normal operating position and the load spring balancing the force due to the centrifugal couple of the flyweights. As an increase in transformed pressure opens the motive fluid valve wider to increase the speed, the governing speed range is varied by adjusting the load spring, maximum speed occurring with maximum spring compression and the speed being reduced by reducing the compression.

As a speed governor operates in response to speed change to oppose change in speed, in the present arrangement, a change in centrifugal force is transformed into a change in liquid pressure, which is used to secure force amplification in the ratio of the relay pressure area to the pressure-responsive means pressure area. In both the direct and inverse arrangements, a change in speed brings about a change in motive fluid admission so as to oppose the speed change, the transformed pressure being increased with increase in speed to reduce the motive fluid admission, and vice versa, in the case of the direct arrangement, and being reduced with increase in speed to reduce the motive fluid admission, and vice versa, in case of the inverse arrangement.

In both the direct and inverse arrangements, as diagrammatically indicated in Figs. 14 and 15, the leaf spring 14 takes up a position to place the forces acting thereon in equilibrium, such forces being

(1) Leaf spring tension force, "t. f."
(2) Centrifugal force of flyweights, "c. f."
(3) Pressure force of liquid acting on relay pressure area, "p. f."
(4) Load spring force, "s. f."

With the direct arrangement, equilibrium is attained with the centrifugal force and load spring force acting in a direction to increase the transformed pressure equal and opposed to liquid pressure force and leaf spring tension force tending to reduce such pressure. On the other hand, with the inverse arrangement, since the flyweights are oppositely arranged with respect to the fulcrum or bending portion of the leaf spring to give a centrifugal couple in the opposite direction, the centrifugal force is reversed as compared to the direct arrangement, that is, it acts in a direction to reduce the transformed pressure, so that equilibrium is attained with the load spring force tending to increase the transformed pressure being equal and opposed to centrifugal force, leaf spring tension force, and fluid pressure force tending to reduce such pressure. Since increase in transformed pressure is used to reduce the admission of motive fluid in the direct arrangement, the effect of increasing the load spring force is to bring about increase in transformed pressure to reduce the speed. Therefore, with the leaf spring suitably preset, maximum governing speed occurs with the load spring adjusted for zero or minimum force and the governing speed is reduced by increasing the load spring force. On the contrary, with the inverse arrangement, since the centrifugal force acts in the opposite direction and an increase in transformed pressure is used to increase the admission of motive fluid to increase the speed, and without any presetting of the leaf spring, an increase in load spring force has the effect of increasing the speed and vice versa.

Prebending of the leaf spring is advantageous with the direct arrangement. With such arrangement, the leaf spring may be prebent to provide a tension force opposing straightening to secure a minimum transformed pressure for operation at the maximum governing speed, the load spring then being adjusted to its zero or minimum value, with the result that the load spring is adjustable to exert force from the zero or minimum value to a maximum value to reduce the governing speed correspondingly. On the other hand, with the inverse arrangement using a straight leaf spring or one which is not preset, the tension force of such spring is zero in its normal operating position; and, with the load spring balancing the force due to the centrifugal couple of the flyweights, the load spring exerts its maximum force for the maximum governing speed and such spring force is reduced by adjustment of the spring to reduce the governing speed.

While the invention has been shown in several forms, it will 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.

What is claimed is:

1. In governing apparatus for a prime mover provided with a rotary member, means providing a controlling liquid pressure space; means carried by and rotatable with the rotary member and including a valve movable axially of the member to vary the pressure in said space; and a leaf spring and flyweight aggregate connected to the rotary member and abutting the valve; said aggregate including a leaf spring having inner and outer attachment portions joined by a flexible portion, means for connecting the outer attachment portion to the rotary member so that the leaf spring is disposed substantially in a rotational plane of the latter and intersects the axis thereof, and weight means connected to the inner attachment portion and arranged to respond to centrifugal force to cause the aggregate to exert thrust on the valve to effect change in space pressure dependent upon centrifugal force change, said weight means being comprised by a pair of weights attached to opposite faces of the leaf spring and having their centers of gravity at diametrically opposite sides of the rotary member axis and spaced from opposite faces of the leaf spring with the centers of gravity arranged in a plane which intersects the flexible portion of the leaf spring lengthwise.

2. In governing apparatus for a prime mover provided with a rotary member, means providing a controlling liquid pressure space: means carried by the rotary member and including a valve movable axially of the member to vary the pressure in said space and having a pressure area subject to space pressure: a leaf spring and flyweight aggregate connected to the rotary member and abutting the valve: said aggregate including a leaf spring having inner and outer attachment portions joined by a flexible portion; means for connecting the outer attachment portion to the rotary member so that the leaf spring is disposed substantially in a rotational plane of the latter and intersects the axis thereof; and a pair of weights connected to the inner attachment por-

tion of the leaf spring at opposite sides of the latter with the centers of gravity of the weights at diametrically opposite sides of the rotary member, spaced from opposite faces of the leaf spring, and arranged in a plane intersecting the flexible portion of the leaf spring longitudinally so that centrifugal force acting on the weights is effective to apply a centrifugal couple to the aggregate to cause the latter to exert thrust on the valve to effect change in space pressure dependent upon centrifugal force change: a load spring for exerting force on the aggregate to provide for space pressure dependent upon the loading of the load spring: and means for adjusting the load spring.

3. In a governor, means providing liquid under governing pressure and including a relay operable to vary the pressure: a drive shaft rotatable with apparatus whose speed is to be governed and provided with a head: said head including a flange connected to the drive shaft, a spacing member comprising end ring portions joined by an arcuately-extending portion to provide a clearance space, a ring member, and means for attaching one ring portion to the flange and for attaching the ring member to the other ring portion; and means for applying forces to the relay to operate the latter to provide governing pressure dependent upon rotational speed of the drive shaft and including an area formed on the relay and subject to liquid under governing pressure so that force is applied to the relay in a direction to effect reduction in governing liquid pressure and including apparatus for applying to the relay force which varies in response to rotational speed of the drive shaft and which cooperates with the liquid pressure force to operate the relay to vary the governing liquid pressure in response to rotational speed of the drive shaft: said apparatus including a leaf spring having inner and outer attachment portions joined by a flexible portion with the outer attachment portion connected to the head by being clamped between the ring member and the other ring portion so as to extend substantially in a rotational plane of the drive shaft and be engageable with said valve member to apply force to the latter; a pair of weights each having a foot adapted to fit against one side of the leaf spring; and means for clamping together the feet of the weights and the inner attachment portion of the leaf spring with the weights disposed at opposite sides of the spring and with one of the weights located in the clearance space of said spacing member so as to leave the flexible portion of the leaf spring free for deflection; said weights having their centers of gravity at diametrically opposite sides of the drive shaft axis, spaced from opposite faces of the leaf spring, and in a drive shaft axial plane intersecting said flexible portion in the direction of its length to provide for the weights being statically balanced with respect to the drive shaft and for the development of a couple due to centrifugal force of the weights tending to deflect the leaf spring laterally to apply force to the valve member dependent upon speed of the drive shaft.

4. In a governor, means providing a space for liquid under governing pressure; a drive shaft rotatable with apparatus whose speed is to be governed and having an axial bore forming a portion of said space and said bore opening through one end of the drive shaft to provide a discharge port; a plunger coaxial with the drive shaft; means connected to rotate with the drive shaft and guiding the plunger for axial movement; a

cup valve carried by one end of the plunger and arranged in covering relation with respect to said discharge port to control the escape of liquid from the latter and presenting an area subject to space pressure so that force dependent upon the latter is applied to the cup valve in a direction to open the latter to lower the space pressure; a leaf spring having inner and outer attachment portions joined by a flexible portion; means for connecting the outer attachment portion to the drive shaft so that the leaf spring extends substantially in a rotational plane of the latter and intersects the axis of rotation thereof; a pair of weights; and means for attaching the weights to opposite sides of the inner attachment portion of the leaf spring with the centers of gravity thereof arranged at diametrically opposite sides of the drive shaft axis, spaced from opposite faces of the leaf spring, and having their drive shaft axial plane intersecting the flexible portion lengthwise to provide for a statically-balanced relation of the weights with respect to the drive shaft axis and for the development of a couple tending to deflect the leaf spring laterally to apply force to the plunger dependent upon speed of the drive shaft.

5. Apparatus as claimed in claim 4 with a load spring exerting force on the plunger to act on the cup valve to provide governing pressure dependent on the force and means for adjusting the load spring to vary the force applied thereby to the plunger to vary the governing liquid pressure in order to adjust the governing speed over a suitable range.

6. In a governor, means providing a space for liquid under governing pressure; a drive shaft rotatable with apparatus whose speed is to be governed and having an axial bore forming a portion of said space and said bore opening through one end of the drive shaft to provide a discharge port; a plunger coaxial with the drive shaft; means carried by the rotary member and guiding the plunger for movement axially of such member; a cup valve carried by one end of the plunger and arranged in covering relation with respect to the discharge port to control the escape of liquid from the latter and presenting an area subject to space pressure so that force dependent upon such pressure is applied to the cup valve tending to move the latter in an opening direction to lower the space pressure; and means for applying force to the plunger in opposition to said opening force and including a leaf spring having inner and outer attachment portions joined by a flexible portion, means for connecting the outer attachment portion to the drive shaft so that the leaf spring extends substantially in a rotational plane of the drive shaft, a pair of weights, means for attaching the weights to the inner attachment portion at opposite sides of the leaf spring with the centers of gravity of the weights disposed at opposite sides of the drive shaft axis, spaced from opposite faces of the leaf spring, and in a drive shaft axial plane intersecting the leaf spring longitudinally to provide for a statically-balanced condition of the weights and for the development of a couple tending to deflect the leaf spring laterally to apply force to the plunger in opposition to the liquid pressure force applied thereto.

7. In a speed governor for a machine having a rotary element, controlling means for the machine and including a force-responsive member and a leaf spring and weight aggregate abutting the member to apply force thereto; said aggregate including a leaf spring having inner and

outer attachment portions joined by a flexible portion, means for connecting the outer attachment portion to the rotary element so that the leaf spring extends substantially in a rotational plane of the latter and intersects the axis of rotation thereof, and a pair of weights connected together and to the inner attachment portion of the leaf spring, said weights extending in opposite directions from the rotary element axis and having their centers of gravity spaced from opposite faces of the leaf spring and in an axial plane of the rotary element so that the centrifugal force of one weight may balance that of the other except for the centrifugal couple of the weights applied to the leaf spring to cause the aggregate to exert force on said member.

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