June 9, 1953 A. NILSEN ET AL 2,641,441

TURBINE GOVERNOR

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FIG.1

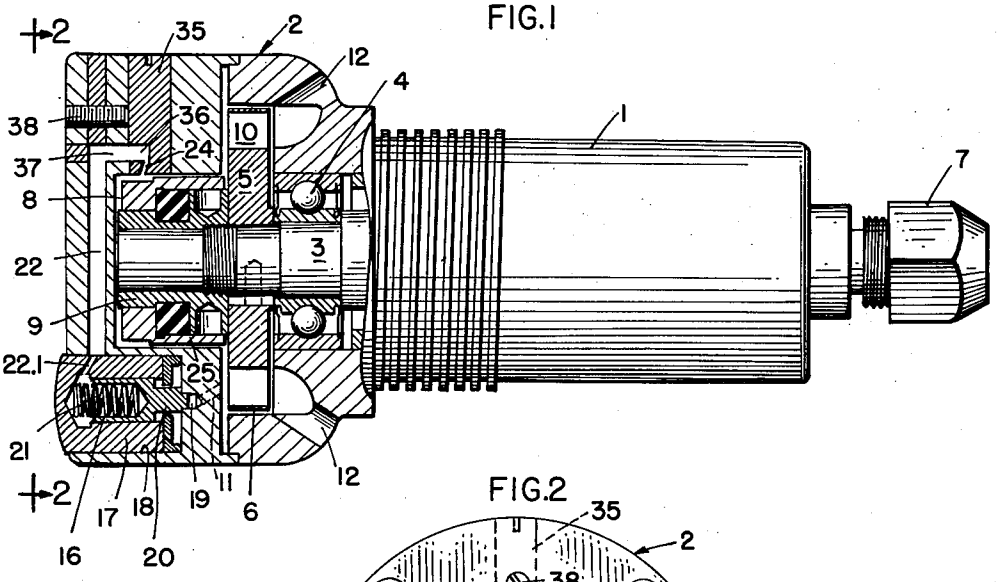


FIG.2

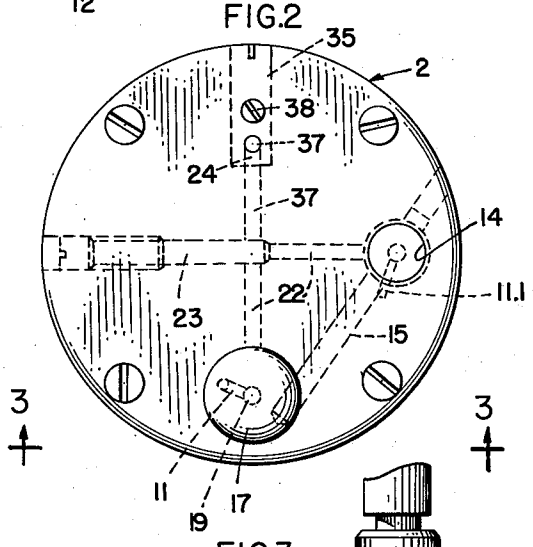
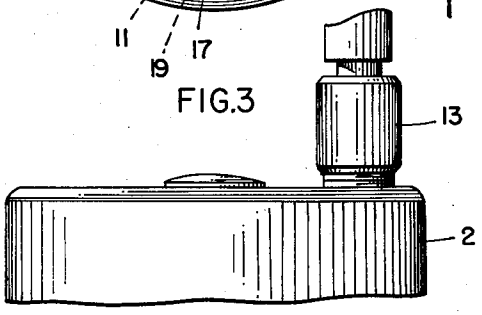


FIG.3



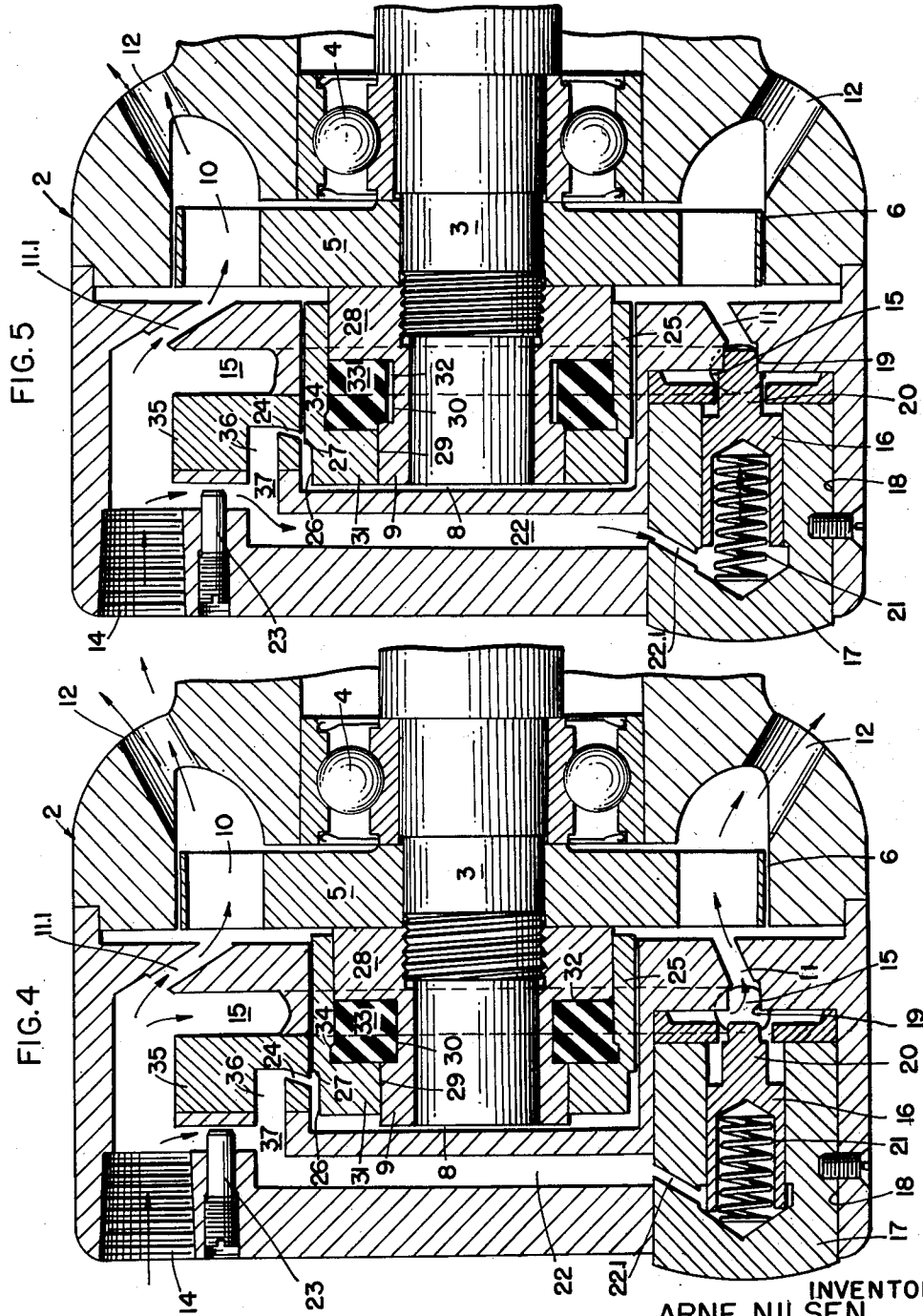
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TURBINE GOVERNOR

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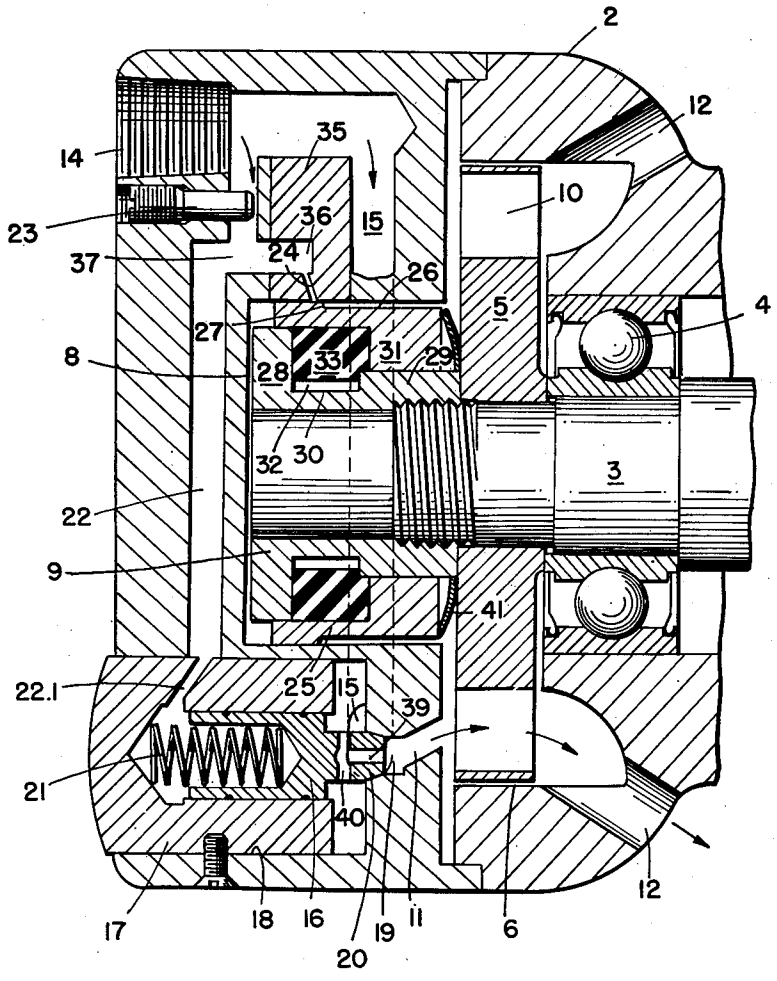
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TURBINE GOVERNOR

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FIG. 6



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UNITED STATES PATENT OFFICE

2,641,441

TURBINE GOVERNOR

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Application February 21, 1951, Serial No. 212,148

9 Claims. (Cl. 253—59)

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This invention relates to governors for high speed fluid driven turbine wheels and particularly to governors or regulators for automatically controlling the driving fluid input according to load variations so as to maintain a substantially constant speed.

The main objects of this invention are to provide an improved governor for high speed rotors; to provide an improved centrifugally actuated governor; to provide such a device for more accurately controlling a fluid-pressure actuated rotary mechanism; to provide such a device for controlling the fluid-pressure input of a turbine; and to provide an improved centrifugally actuated governor for automatically regulating the power input to high speed turbines according to variations of load conditions.

Further objects of this invention are to provide an improved centrifugally actuated governor for automatically maintaining a substantially constant speed in a high speed turbine under normal variations of load conditions; to provide an improved centrifugal governor, for high speed rotors, having few parts and of simple cheap construction; to provide an improved rotary governor wherein centrifugal force acting on a radially confined actuator is directed axially to operate a power input control device; and to provide such a governor that is capable of close adjustment for sensitivity to speed variations.

A specific embodiment of this invention is shown in the accompanying drawings in which:

Figure 1 is a partly sectional view, in side elevation, showing a turbine driven tool embodying the invention.

Fig. 2 is an end view of the same, as taken from the line 2—2 of Fig. 1, showing the location of drilled air passage holes in dotted outline.

Fig. 3 is a fragmentary bottom view of the same as taken from the line 3—3 of Fig. 2.

Fig. 4 is an enlarged fragmentary axial sectional view of the motor end of the device of Fig. 1, showing the improved governor in starting or loaded position and showing a schematic arrangement of the several air passages.

Fig. 5 is a view similar to Fig. 4 showing the governor in full speed position, and

Fig. 6 is a view similar to Fig. 4 showing a modified arrangement of the improved governor.

The present invention is an improvement on the device disclosed in Patent No. 2,426,045 granted August 19, 1947, to Rudolph F. Onsrud for Rotor Governor and utilizes a similar principle for controlling the fluid-pressure input to a turbine type power unit for regulating its speed

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under changing load conditions, the improvement being particularly concerned with the governor actuating means and means for adjusting the sensitivity of response to load or speed change.

In the form shown in the drawings the improved governor is embodied in a high speed turbine driven tool comprising a body 1 having a motor head 2 at one end, a spindle or shaft 3 extending axially in the body and journaled in suitable bearings, one of which is shown at 4, and a turbine wheel or rotor 5 mounted fast on the shaft 3 in a suitable chamber 6 formed in the motor head 2. The shaft 3 extends from the end of the body 1 opposite the motor head and carries a chuck 7 on its outer end. The inner end of the shaft 3 extends into a second or control chamber 8 in the motor head and is threaded, adjacent its end, to receive an elongated cylindrical carrier member or nut 9 by which the rotor 5 is securely clamped onto the shaft 3 and against the inner race of the bearing 4.

The turbine wheel or rotor 5 is provided with the usual annular series of bucket blades 10 located in its outer margin and is driven by a jet of fluid directed against the blades from a suitable nozzle 11 formed in the body of the motor head and disposed to direct the jet into the blades in a direction substantially tangential to the path of the blades in the direction of rotor rotation. Also the motor head or housing 2 is provided with appropriate exhaust outlets 12, on the side of the rotor opposite the nozzle 11, located to discharge the driving fluid as soon as it passes through the rotor blades.

Fluid under pressure, in this case air, is supplied to the nozzle 11, by a supply line or pipe 13 connected to an inlet 14, which in turn communicates with the nozzle 11 through a passage 15 formed within the motor head 2, and the usual stop valve, not shown, is provided in the supply line for admitting or cutting off the supply of fluid. Communication between the passage 15 and the nozzle 11 is controlled by an internal pressure actuated valve 16, which in turn is slidably disposed in a cup-like valve retainer 17 mounted in a bore 18 extending inwardly from the end of the motor head and intersecting the passage 15. The nozzle 11 leads from a bore 19, axially aligned with the bore 18 at its inner end, and the valve 16 is provided with a stem 20 which controls the passage of fluid through the bore 19.

The valve 16 is normally held in closed position, closing the bore 19, by means of a compression sping 21, which is disposed in an axial recess in the valve body and bears between the

valve body and the closed end of the retainer 17, and the valve is actuated by a differential of fluid pressure exerted against its opposite ends. Pressure on the forward end of the valve is obtained from the direct exposure thereof to the supply line pressure at the intersection of the bore 18 and the passage 15; and pressure on the rear end of the valve is supplied by way of a branch passage 22 which leads from the supply inlet 14 and into an opening 22.1 drilled through the wall of the retainer 17. A choke 23 may be provided in the passage 22 to adjust the rate of fluid flow therethrough and a bleed passage 24 is provided which communicates with the branch passage 22 and opens into the control chamber 8 through the side wall thereof, the chamber 8 having communication with atmosphere and the lower pressure thereof by way of the peripheral clearance space about the member 25, mounted on the shaft 3, which opens to the rotor chamber 6.

Thus when the bleed passage 24 is open the fluid pressure on the rear of the valve 16 is reduced and the full supply line pressure on the forward end of the valve is sufficient to overcome the spring 21 and force the valve to the open position shown in Figs. 1 and 4; and when the bleed passage 24 is closed the full line pressure is applied on the rear end of the valve and, together with the spring 21, forces the valve to the closed position shown in Fig. 5. It is the function of the improved governor, hereinafter described, to control the bleed port 24 and hence the operation of the nozzle valve 16.

In the construction shown in Figs. 1 to 5 inclusive, there are two nozzles 11 and 11.1, for directing jets of fluid into the rotor buckets, the second nozzle 11.1 leading directly from the inlet 14 and being uncontrolled. In this case the valve 16 serves to open and close the nozzle 11, according to the operation of the governor, as the need for more or less fluid pressure on the rotor is required to maintain the desired speed or power.

In this construction the governor comprises a cylindrical sleeve 25 slidably mounted over the nut 9, in the control chamber 8, the sleeve having a running clearance with the side wall of the chamber 8, which in turn is of cylindrical form. The sleeve extends axially in the chamber 8, overlapping the bleed port 24, and the portion opposite the bleed port and extending to the rear end of the sleeve is of reduced diameter, as at 26. This provides a shoulder 27, which is normally forward of the bleed port, and a clearance area for the flow of pressure fluid from the bleed port into the chamber 8 and thence to the rotor chamber 6 where it is passed to atmosphere through the blades of the rotor 5 and the discharge ports 12. The pressure fluid from the nozzles 11 and 11.1 drives the rotor by jet impact and passes through the rotor blades directly to the outlets 12, and for that reason the pressure within the rotor chamber 6 is greatly reduced from that in the control passages of the motor head 2, so that the chamber 8 is under a lesser pressure at all times.

As shown the carrier or inner governor member, which in the present instance is the nut 9, has an annular collar or flange at each end, the forward collar 28 being of greater diameter than the rearward collar 29 so that a peripheral channel 30 is provided between the collars. The sleeve 25, or outer governor member, slidably fits over the collar 28 and at its rearward end is provided with an inwardly projecting flange portion or abutment means 31 which slidably fits over the collar 29. Thus an enclosed cavity 32 is formed, between the carrier or nut 9 and the sleeve 25, within which the governor actuator is disposed.

In the form shown the governor actuator comprises an annular ring-like body 33, made of an elastic centrifugally expansible material capable of changing its shape under the influence of its inherent centrifugal force of rotation and of returning to its original shape when the force ceases to act. Normally the elastic body 33 completely fills the cavity 32, when the parts are at rest, as shown in Fig. 4. However, when the parts are rotating at high speed, as when the shaft 3 is driven by the turbine rotor 5, the centrifugal force acting on the mass of the body 33 will cause it to flow or spread radially outward so that being radially confined, it will expand axially along the inner surface of the shiftable sleeve 25 and exert its expansive force between the roller 28 and the flange 31. This results in axial movement of the sleeve 25, relative to the nut 9 which is fixed on the shaft 3, in direct accordance with the speed of rotation, so that ultimately the shoulder 27 on the sleeve will be moved to a position to close or cut-off the bleed port 24. This in turn, results in the operation of the valve 16 to control the jet nozzle 11, and hence the speed of the rotor, as before described.

The governor actuator may be made of any elastic material or form capable of the function of distorting radially, under the influence of centrifugal pressure, and thereby expanding axially when radially confined. For example natural or synthetic rubber may be used and in practice a solid synthetic rubber ring having a No. 35 durometer hardness has been found to be satisfactory where the operating speed of the shaft is around 50,000 R. P. M.

In the form shown in Figs. 1 to 5 inclusive, the sleeve 25 is undercut on its inner wall, as at 34, to provide a peripheral channel into which the material of the actuator 33 extends at all times. This provides an interlock between the actuator and the sleeve so that return or retrograde movement of the sleeve will be assured whenever the actuator elastically returns toward, or resumes, its original shape upon decline or cessation of the distorting centrifugal force acting on the actuator body. The actuator is anchored to the collar 9 by the channel 30 in which it is normally seated.

As shown in Fig. 1, and as indicated in Figs. 4, 5 and 6, the bleed port 24 is formed in a cylindrical plug 35 and leads from a lateral bore 36 in the plug, which bore communicates, through a passage 37, with the branch passage 22. The port 24 is formed at an angle with the axis of the plug so that its opening at the end of the plug is eccentrically located. This permits adjustment of the bleed port location, relative to the shoulder 27 on the governor sleeve 25, for accurate calibration of the speed at which cut-off occurs. Adjustment of the plug is had by rotating the plug with a screw driver or other suitable tool and when the desired adjustment is obtained the plug is locked by means of a set screw 38 shown in Fig. 1.

In the construction shown in Fig. 6 only the one nozzle 11 is employed to drive the rotor 5 and speed control is had by varying the amount of fluid under pressure that is delivered by the sin-

gle nozzle. In this case the stem 20 of the valve 16 is provided with a central bore 39, or by-pass, which opens at the end of the stem and which connects with a cross bore 40 opening into the bore 18 at the inner end of the retainer 17. Thus fluid under pressure is supplied to the nozzle 11 at all times whether the valve 16 is in open position, or is closed as shown in Fig. 6.

Upon actuation of the valve 16 to open position, when the bleed port 24 is open, as at starting or when rotor speed is reduced by an increased load on the spindle 3, the port 19 is fully opened and the maximum amount of pressure fluid is supplied to the nozzle. When the bleed port is closed by the governor, as maximum rotor speed is attained, the valve 16 shifts to closed position and reduces the amount of pressure fluid entering the nozzle 11 to capacity of the by-pass 39.

The advantage of this arrangement is greater sensitivity of speed control and response to action of the governor, since the valve 16 can float between open and closed positions and provide an infinite variation between the maximum and minimum amounts of fluid supplied to the nozzle 11.

Also Fig. 6 shows a modification of the governor construction which may be used for control of the bleed port. In this form the assembly of the nut 9 and sleeve 25 is reversed on the end of the shaft or spindle 3 so that the movement of the sleeve 25, under the expansive influence of the actuator, is toward the rotor 5. This permits the use of a spring washer 41 between the sleeve and the rotor which spring provides a positive, fast acting, return of the sleeve in the retrograde or port opening direction upon elastic retraction of the actuator. Since the sleeve, nut and rotor all turn with the shaft or spindle 3 there is no relative angular movement between these parts. In this case the reduced portion 26 of the sleeve 25 extends to the forward end thereof from the cut off shoulder 27, since the sleeve moves forwardly under the influence of the actuator.

The main advantages of this invention reside in ruggedness, simplicity and compactness of the governor construction and in the simplicity and comparatively low cost of the governor actuator, whereby the governor may be readily employed for controlling a wide variety of devices driven by fluid under pressure. Other advantages are to be found in sensitivity of the governor to changes in operating speeds and in the rapid control of the driving power whereby normal speed is maintained substantially constant under all ordinary operating conditions; and in the improved governor construction which permits easy calibration and adjustment for both operating speed and sensitivity.

Although two specific embodiments of this invention are herein shown and described it will be understood that numerous details of the constructions shown may be altered or omitted without departing from the spirit of this invention as defined by the following claims.

We claim:

1. A centrifugal governor comprising a rotary member, a centrifugally expansible elastic annular body driven by said rotary member and secured with one end in fixed relation therewith, an axially shiftable sleeve surrounding and radially confining said body, inwardly projecting means on said sleeve engaging the other end of said body endwise, said body being expansible axially upon actuation by the centrifugal force of rotation thereof to shift said sleeve axially, and means interlocking said sleeve and the said other end of said body for causing retrograde motion of said sleeve upon elastic retraction of said body during decline of the centrifugal force acting thereon.

2. A device of the class described comprising a rotatable shaft, an annular elastic body mounted on said shaft and projecting radially therefrom, a collar fast on said shaft and abutting one end of said body, an axially shiftable sleeve encircling said body to confine the same radially and having an inwardly projecting portion abutting the other end of said body, said body being centrifugally expansible axially to shift said sleeve axially relative to said shaft, means for holding said body in abutment with said collar, and means on said sleeve having interlocking engagement with said body adjacent the said other end thereof.

3. A device of the class described comprising a rotatable shaft, a solid annular elastic body mounted on said shaft and projecting radially therefrom, collar means fast on said shaft and axially abutting one end of said body, means for retaining said body and collar means in abutment with each other, axially shiftable means abutting the other end of said body, means peripherally encircling said body to confine the same radially, said body being expansible upon actuation by the centrifugal force of rotation thereof to move said shiftable means axially away from said collar, and means connecting said body and said shiftable means for causing retrograde axial movement of said shiftable means during recession of such centrifugal force.

4. A centrifugal governor control unit comprising a carrier adapted to be fixedly mounted on a rotary member concentric with the axis of rotation thereof, a flange fixed on and projecting radially outward from said carrier, a solid centrifugally expansible elastic body concentrically mounted on said carrier in endwise abutment with said flange, an axially shiftable member abutting the end of said body opposite said flange, means encircling said body to confine the same radially, said body being expansible axially under the influence of the centrifugal force of its rotation to move said shiftable member axially relative to said carrier, and means on said carrier for holding said body in continuous abutting engagement with said flange.

5. A centrifugal governor control unit comprising a carrier member adapted to be fixedly mounted on a rotary element concentric with the axis of rotation thereof, a flange fixed on and projecting radially outward from said carrier, a solid centrifugally expansible elastic annular body concentrically mounted on said carrier in endwise abutment with said flange, an axially shiftable member slidably mounted on said carrier and abutting the end of said body opposite said flange, axially extending means on one of said members peripherally enclosing said body to confine the same radially, said body being expansible axially under the influence of the centrifugal force of its rotation to move said shiftable member axially relative to said carrier member, means on said carrier member for retaining said body in abutment with said flange continuously.

6. A centrifugal governor control unit comprising an annular carrier member adapted to be fixedly mounted concentrically on a rotary element, said carrier having a pair of axially spaced radial

collars defining a peripheral channel between them, one of said collars being of greater diameter than the other collar, a centrifugally expansible elastic annular body seated in said channel and projecting radially beyond said other collar, an axially shiftable member slidably mounted on said other collar and axially abutting said body, and axially extending means on one of said members peripherally surrounding said body and confining the same radially, said body being expansible axially under the influence of centrifugal force to move said shiftable member axially relative to said carrier member.

7. A centrifugal governor control unit comprising an annular carrier member adapted to be fixedly mounted concentrically on a rotary element, said carrier having a pair of axially spaced radial collars defining a peripheral channel between them, one of said collars being of greater diameter than the other collar, a centrifugally expansible elastic annular body seated in said channel and projecting radially beyond said other collar, an axially shiftable member slidably mounted on said other collar and axially abutting said body, axially extending means on one of said members peripherally surrounding said body and confining the same radially, said body being expansible axially under the influence of centrifugal force to move said shiftable member axially relative to said carrier member, and means for causing retrograde movement of said shiftable member upon elastic retraction of said body during decline of the centrifugal force acting thereon,

8. In a fluid pressure actuated rotary mechanism having a rotary shaft, a pressure driven wheel fast on said shaft, a housing for enclosing said wheel, a nozzle in said housing for directing fluid in driving relation to said wheel, and means including a passage in said housing for supplying fluid under pressure to said nozzle, said housing having a cylindrical chamber axially aligned with said shaft, an automatic governor comprising an annular centrifugally expansible elastic body rotatively driven by said shaft and disposed within said chamber, axially fixed means on said shaft abutting one end of said body, annular axially shiftable means abutting the opposite end of said body, one of said means having an axially extending collar enclosing said body peripherally and confining the same against radial expansion, said body being expansible axially under the action of its centrifugal force of rotation to move said shiftable means axially, a sliding valve actuated by pressure differential at its ends and having one end extending into said fluid supply passage for conrolling the flow of fluid to said nozzle, a conduit for fluid leading

from said supply means to the other end of said valve, a cylindrical plug in said housing disposed normal to the axis of said chamber and having its inner end disposed with running clearance from the periphery of said shiftable means, said plug having a passage therein opening at the inner end of the plug and eccentric with respect to the axis thereof, a bleed duct leading from said conduit into the passage in said plug, the end opening of said plug being located in the path of said shiftable means for closure thereby upon axial movement of said shifting means through centrifugal expansion of said body, and means for rotating said plug to vary the axial relation of the plug end opening and said shiftable means.

9. A centrifugal governor control unit comprising an annular carrier member adapted to be fixedly mounted concentrically on a rotary element, said carrier having a pair of axially spaced radial collars defining a peripheral channel between them, one of said collars being of greater diameter than the other collar, a centrifugally expansible elastic annular body seated in said channel and projecting radially beyond said other collar, an axially shiftable member slidably mounted on said other collar and axially abutting said body, axially extending means on said shiftable member peripherally surrounding said body and confining the same radially, said body being expansible and contractible axially under the influence of centrifugal force to move said shiftable member axially relative to said carrier, the inner wall of said axially extending means having an annular groove adjacent said shiftable member for interlocking engagement with the periphery of said body.

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