

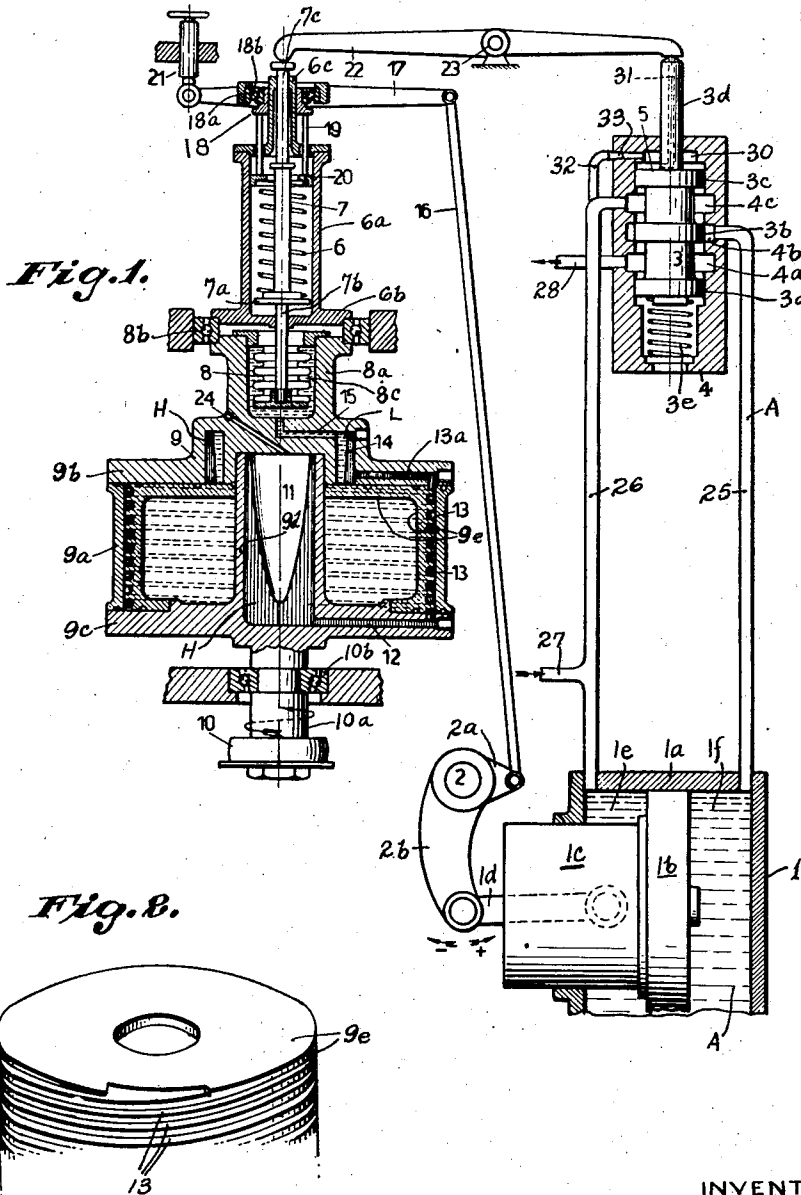
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MOTOR SPEED GOVERNOR

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MOTOR SPEED GOVERNOR

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The present invention is a novel motor speed governor, and particularly concerns a mode of operation and apparatus for governing the speed of internal combustion and other motors; the invention making use simultaneously of the action of rotary velocity and of the action of angular acceleration. The invention is shown in an embodiment making use of a mass of a heavier liquid, as mercury, which is predominantly subject to the actions of velocity and of acceleration, and as well a lighter liquid or oil serving as a transmission means, both the heavy and light liquids being contained in the rotary portion or vessel of proper shape, maintained in variable rotation by the motor to be governed, and having certain chambers including a compartment within which the heavy and the light liquids operatively meet, supplemented by a peripheral chamber, conduit or the like wherein angular accelerations may operate to modify the heavier liquid pressure generated by centrifugal force and from which the motor control is taken.

One embodiment of the invention is illustrated diagrammatically in the drawing, as an example, this representing the principles but not limiting the invention, Fig. 1 shows the apparatus in elevational section, assumed to be operating at normal high speed; the heavy liquid H being represented with vertical lines, the light liquid L by horizontal lines. Fig. 2 is a perspective view of the grooved drum to be described.

Referring to said drawing, the governor comprises a servo-motor 1, operating with oil or other liquid A under pressure, connected to the motor-controlling shaft 2, whose rocking movement, in one direction or the other, increases or reduces the power of the motor, as by opening the throttle more or less. In the cylinder 1^a of the servo-motor operates the oil piston 1^b, whose enlarged stem or rod 1^c is connected by rod 1^d with rockarm 2^b on shaft 2. The cylinder encloses the oil space 1^e surrounding the stem 1^c and the larger oil space 1^f beyond the piston. The control shaft 2 has the rockarm 2^b mentioned and a second rockarm 2^a to which is pivoted a link or pull-rod 16 to be described.

A piston and valve device 3—4 operating with oil or any other liquid is arranged to adjust the position of servo-motor 1 according to the requirements of the speed regulation under the control to be described. An auxiliary servo-motor 5, operating under the pressure of oil or any other liquid is connected directly to or co-operates with the device 3—4, and functions to

provide supplemental power to the action of the accelero-tachimetric governor 9 to be described.

The valve device 3—4 comprises a piston 3 movable in a cylinder 4. The piston has a lowest flange 3^a, middle flange 3^b and top flange 3^c with piston spaces or grooves between them, and at the top a rod 3^d passing through the top wall of the cylinder 4, while below the piston is a spring 3^e constantly urging upwards these parts, causing rod 3^d to press against an overhead lever 22 to be described. The cylinder contains annular chambers or channels controlled by the piston flanges, including a lowest annular channel 4^a, middle channel 4^b and top channel 4^c.

The servo-motor 1 and valve 3—4 are in operative communication with each other and with other parts, for example as follows. An oil pipe 25 extends with variable pressure between motor chamber 1^f and valve channel 4^b, and a pipe 26 connects with constant pressure the chamber 1^e and channel 4^c. A pipe 27 leads from a conventional hydraulic pressure source or forced supply at constant pressure to the pipe 26. A pipe 28 leads back from the exhaust channel 4^a to the oil supply or escape. Above the piston top flange 3^c is an oil chamber 30, and this communicates at variable pressure with a small oil duct 31 inside the plunger or rod 3^d, said duct ascending for top discharge against the underside of the lever 22 which obstructs the outflow when the two are in pressing contact. Between chamber 30 and supply pipe 26 extends also a small oil pipe 32 containing a flow restriction.

The auxiliary servo-motor 5, in the nature of a pilot valve, consists of the top side of the top flange 3^c of the piston, working in the variable-pressure chamber 30, the plunger 3^d with interior oil passage 31 discharging against the end of lever 22, and the small pipe 32 supplying oil to chamber 30, this provided with a suitable restriction 33, as an orifice to reduce greatly the flow between the chamber and supply, or even a checkvalve to prevent outflow. The oil in this chamber restrains the lifting of piston 3 by spring 3^e except when the rise of lever 22 permits free oil escape; and so the piston follows the movements of the lever, and in turn controls the oil flow to and from the servo-motor, and therefore the action of the latter for throttling or regulating the motor and for cooperation with the accelero-tachimetric governor 9.

Said governor 9, rotated by the governed motor through pulley 10, contains a central or primary chamber 11, partly filled by a heavy liquid

H, preferably mercury. This communicates with an annular compartment 14 through a radial conduit 12 and then a circumferential and preferably helical conduit 13. Said compartment 14 is shown filled with liquid, partly by the same heavy liquid as chamber 11 and partly by oil or other light liquid L. The annular compartment communicates in turn, by means of a radial or inwardly extending conduit 15, with a central secondary chamber 8^c.

The secondary chamber 8^c is pressure responsive, carrying or containing a diaphragm 8, shown as a bellows diaphragm, mounted inside of a casing 8^a formed as a walled extension of the main governor casing. The upper end of the bellows is tightly fixed to the casing 8^a and its lower end, moved by the pressure changes of the surrounding oil, rises or falls and so actuates the rods 7^b and 7 and parts beyond. The mechanical parts forming the governor and represented in the drawing, are connected one to another so as to secure perfect tightness of the vessel containing the heavy and the light liquids. Hole 24 is used for filling up the apparatus, and various plugs close the outer ends of bored passages.

The rotary mountings include a ball bearing 8^b near the top of the secondary chamber wall 8^a, and, around the depending shaft 10^a which carries the pulley 10, a thrust bearing 10^b below the primary chamber casing. About the axis of these the entire governor rotates.

The main portion of the governor, within which is the primary chamber 11, comprises a built-up structure, described as follows. Its cylindrical outer wall or casing 9^a extends between its upper head 9^b and lower head 9^c, all preferably separate pieces tightly joined. An interior rising extension 9^d of the under head provides a cylindrical wall enclosing the primary chamber, containing the mercury. Confined between parts 9^a, 9^b and 9^c is a walled member or drum 9^e, shown detached in Fig. 2, having a driving fit in the casing wall 9^a and with an upper flange reaching in to the chamber wall 9^d. Between the drum 9^e and casing wall 9^a is a circumferential space or conduit 13 of ample radius, and shown of helical form for conducting heavy liquid in its flow between the primary chamber 11 and compartment 14.

The complete liquid connections may be as follows. When under fast rotation the mercury in the primary chamber flows outward through radial passage 12 into rising conduit 13, and takes a vortex shape in the chamber as indicated. The centrifugal force causes upflow through the helical conduit, which in turn delivers into an inwardly extending passage 13^a in the head casting 9^b, this terminating in the lower part of the annular compartment 14. Said compartment always contains both oil and mercury, in pressure-communicating relation, and when idle the mercury settles, but at fast rotation centrifugal force overcomes gravity and the heavy liquid lies in an outer zone, the light liquid in an inner zone, as indicated. From an upper inner part of compartment 14 extends inwardly the passage 15 leading to the oil-filled secondary chamber 8^c, which is in axial position, and the pressure in which gives control through the bellows-type or Sylphon diaphragm 8. The operation will be later described.

The remaining parts, interposed between the diaphragm 8, the servo-motor 1, its valve 3-4 and auxiliary servo-motor 5, and a manual con-

troller such as speed-adjusting pedal 21, may next be described as follows.

The deformation of the central Sylphon with flexible walls, by liquid pressure changes is opposed by a spring 6, shown as a helical spring, bearing upwardly on a ring 20 and downwardly on a flange 7^a of a central vertical rod 7, with a depending rod 7^b connecting the diaphragm to the flange and rod 7. Above the rod 7 is a smaller extension rod 7^c the top end of which bears upon the left arm of the overhead or beam lever 22, already mentioned.

The swinging beam lever, mounted upon a central fixed fulcrum 23, is the connection between the governor 9 and the auxiliary control means 5 of the hydraulic oil valve 3-4.

A "staticity device" is also provided, formed by a pull-rod or link 16 extending between rock-arm 2^a and a lever 17, fulcrumed on a collar 18. This collar is provided with ball bearings so that it may rotate with the governor, and it is connected by means of rods 19 to a movable ring 20 forming a seat for the upper end of the spring 6. By these means it is possible to obtain an automatic variation of the reaction of the spring 6, and thus vary the speed of the motor according to the position of servo-motor 1. The spring 6 is arranged inside of a hollow support or casing 6^a extended above the casing 8^a, the lower flange 6^b of casing 6^a mounted on the casing below; and the casing 6^a having an upper head which is extended as a casing 6^c of reduced diameter within which the small rod 7^c can play up and down. The mounting of the lever 17 on the collar 18 is only indirect; the collar being a ring which is surrounded by an outer ring 18^a, with a ball bearing 18^b between them; the lever being fulcrumed on the outer ring and the ball bearing permitting fast rotation of the inner ring along with the parts therebelow.

The speed-adjusting device 21, whether a pedal or other form of adjuster, is provided in order to allow the reaction and result of spring 6 to be varied according to the running speed desired. The action of the lever 17 to lower or let up the upper seat 20 of the spring is controlled jointly by the pedal 21 and by the servo-motor through the connection or rod 16.

The operation of the present invention may be described as follows. During operation at a normal running-speed, the governor may be in the condition shown in Fig. 1.

When there occurs a decrease in the resisting torque or load to be overcome by the motor, as when a motor vehicle enters a downgrade, the motor torque and the resisting torque will become immediately out of balance. This brings about a positive acceleration in the rotation of the motor; and said acceleration affects therefore also the governor 9, whose rotating elements accelerate with the increase in the motor's speed. As this occurs the mass of the heavy liquid H contained in the circumferential conduit 13 has a tendency by inertia to maintain its existing angular velocity and it therefore lags in the angular acceleration of motion.

Now ordinarily, with constant load and speed, the heavy liquid or mercury H revolving in conduit 13, under pressure from the centrifugal force in chamber 11 and passage 12, presses upwardly upon the portion of mercury in passage 13^a, and this pressure is communicated to the mercury in compartment 14, and the mercury has thus assumed a displaced position which has forced the oil L to displace partially the dia-

phragm or responsive device 8. The diaphragm has thus been raised to an intermediate or running position and with it the rods 7^b, 7 and 7^c. In this responsive yield of the diaphragm it has partly overcome the opposing action or downward thrust of the spring 6 as well as the thrust caused by the beam lever 22; and the lever has thus been swung and has acted through the auxiliary servo-motor 5 to lower the valve 3 which controls the main servo-motor 1. Fig. 1 shows these running positions of the parts. It is to be borne in mind that the light oil has some centrifugal action and that the centrifugal action of the mercury is to be considered as the differential between the two; or the net action of the mercury.

On the other hand, with load drop and motor acceleration, the governor also rotates faster, and this increases the differential action of the centrifugal forces between the mercury contained in the radial conduit 12 and the light oil in the radial conduit 15. Said increase of the differential or net action of the centrifugal forces eventually causes outflow and upflow of mercury and also a displacement inwards and upwards of the oil against the Sylphon diaphragm 8, which in its turn causes, by means of the lever 22 and auxiliary servo-motor 5 a downward displacement of the movable part 3 of the oil-valve controlling the main servo-motor 1. Thus a resetting eventually occurs which restores the motor speed to normal.

In the initial phase, however, the action of acceleration is simultaneous with the action of the speed. The acceleration of the governor 9 causes the described relative lag of the mercury in the conduit 13 by its inertia. It thereby presses and flows in the conduit in a direction to trend upwardly along the helix, it being understood that the governor turns clockwise in top view while the helix rises counterclockwise, as shown. The acceleration action and pressure therefore temporarily enhance the centrifugal pressure, lifting the diaphragm to a magnified extent and promptly moving down the valve 3 to cause action of the servo-motor 1.

The downward displacement of the valve element 3 causes through the servo-motor a throttle closing motion of the governing shaft 2. Thereby the motor torque is immediately reduced, while in the meantime there is a persistence in the reduction of the resisting torque, which reduction has caused the speed change; and therefore the out-of-balance relation between motor torque and resisting torque will gradually be decreased to zero. As soon as the balance between said two torques is attained, the action of acceleration ceases, having completed its function, and the servo-motor has normal operation, moderately closing the throttle or other regulating members, under the sole action of the speed, with of course general control by the pedal.

The motor torque tends to drop therefore under the value of the resisting torque and, if the latter has remained constant in the meanwhile, a deceleration (negative acceleration) will begin, and the apparatus will have an action contrary to that already described above, thus reducing the effect caused by the excess of velocity.

These two actions operating always contrarywise, one opposing the other, will prevent any starting of swinging periods and will afford a quicker and smoother attainment of the new conditions of speed and torque.

In the case of an increase in the load, as meet-

ing an upgrade, actions similar to those described above will take place but in the reverse sense.

The device comprising link 16 and lever 17 for staticism, when it reacts on the recoil-spring 6, opposing the deformations of the diaphragm 8, allows a self-adjustment of the normal speed of the motor according to the position of servo-motor 1. Likewise the speed-adjustment device or pedal 21, on reacting on the same recoil spring 6, makes it possible to modify as desired the normal speed of the motor.

It should be noted particularly that the annular compartment 14 has an important function; this having a substantial capacity and containing the dividing surface between the oil and mercury. By the provision of this compartment it is practical to avoid, during an increase of velocity due to the increase in capacity of the Sylphon diaphragm 8, the result that the contact surface between the mercury and oil might shift to a substantial amount towards the axis of rotation, which would unduly vary or decrease the differential effect and operation between the centrifugal pressure developing in the channel full of mercury and the similar pressure developing in the channel full of oil. By its large diameter and section the compartment contains such ample volume that a considerable flow may occur without serious displacement of the boundary surface between the two liquids.

A function of the annular compartment 14 is to increase greatly the area of the parabolic surface of contact between the heavy and the light liquids during their rotation, as compared with the negligible area afforded by contact within a radial passage.

By providing such a chamber, and thereby increasing the surface of contact between the heavy and the light liquids during the operation of the governor, the displacement towards the axis of rotation of said surface of contact is reduced to a minimum, and is negligible, even when the capacity of the Sylphon diaphragm 8 with flexible walls and the displacement of the auxiliary servo-motor 5 undergo major changes. Therefore the consequent impairment or reduction in the differential effect between the pressure developed by centrifugal force on the conduit full of heavy liquid and the pressure developed by centrifugal force in the conduit full of light liquid, will also be minimized.

Another consideration is that, in order to confer practically on the aforesaid apparatus a high sensitivity to the action of acceleration, it is important to give a greatly extended length to the peripheral conduit or the like containing the heavy liquid. It is for this reason that said conduit is wound helically with a number of turns. During an acceleration every part of the length of this long stream of mercury is in operation to afford the described pressure-modifying function.

Finally, in order to maintain indefinitely in the course of time the constancy of the apparatus's behavior, and increase its reliable life, the whole governor vessel, comprising the Sylphon diaphragm 8 with flexible walls, the radial conduit 15, the annular compartment 14, the circumferential conduit 13, the radial conduit 12 and the central main chamber 11, is tightly or hermetically sealed, thus avoiding all mass interchanges between the inside and the outside rotating equipment, both with regard to the heavy liquid, and particularly with regard to the light

liquid, which is confined between the heavy liquid and the diaphragm 8. However the upper central part of the central vessel 11 may be closed, or it may communicate with the atmosphere, admitted above the body of mercury and avoiding vacuum action.

An important aspect of the invention lies in supplementing motor control from its speed by control from its acceleration, which term includes deceleration. For example, a sudden drop of load causes prompt acceleration and therefore throttling, before speed control fully acts. Thus the acceleration control takes care of the brief transition period before speed change can come fully into control. The acceleration control re-establishes at once, and therefore maintains, the balance between the power torque and the resistance or load torque. Hence overregulation and oscillations or pendulum actions are practically eliminated. The operation may be described as immediate acceleration control to maintain the balance between motor and load torques while the speed control acts more gradually to bring the motor to the required speed. The greater the acceleration sensitivity the smaller will be the unbalance between the torques while the motor speed is being returned to normal. The degree of sensitivity to acceleration can be made high or low as desired. The design of the circumferential conduit 13 as to its radius, its volume, and its length is a major factor. This can readily be calculated in advance, on the described principles and for the particular uses in hand, as can also the design of compartment 14, the characteristics of the diaphragm 8 and spring 6 and other parts, and the volumes of heavy and light liquids. The mercury, rather than being a mere transmitter of control, is in fact the operating mass for both tachimetric action and accelerometric action. Note that the liquid action requires no adjustments in use, no orifices or other restrictions and no valves or movable parts (other than of course the responsive diaphragm) and the flow is free and unrestricted. The liquids may be enclosed and sealed in a practically hermetical manner, so there are no losses, nor any admission of impurities to clog or render sluggish the response.

It should be understood that, in practice, constructional details and matters of arrangement, as also the useful applications of the invention, may be varied without thereby exceeding the scope of the invention or the intended domain of the protection of the patent.

What is claimed and desired to be secured by United States Letters Patent is:

1. Motor governing apparatus adapted to act through suitable motor regulating mechanism for governing the speed of the motor under the combined control of its rotary speed and its acceleration, positive or negative, such apparatus comprising a motor-rotated governor formed with a primary chamber containing a relatively heavy liquid subject to centrifugal force developing a liquid pressure varying with the motor speed, and with a secondary chamber containing a relatively light liquid and having a pressure responsive instrument connected for operation of such regulating mechanism, and with passages communicating between said two chambers, said intercommunicating chambers and passages being as a whole closed against loss of liquid; said passages including a compartment into which the heavy liquid extends from said primary chamber and the light liquid extends from said sec-

ondary chamber with the two liquids in pressure-communicating relation in said compartment, and said passages including also a circumferential conduit between the primary chamber and said compartment and filled with the heavy liquid and wherein angular accelerations due to changes of rotary speed cause modifications of the centrifugally produced pressure of such liquid; whereby the heavy liquid pressure so determined jointly by the motor speed and by such angular accelerations is communicated through the light liquid to the secondary chamber to act through said responsive instrument and regulating mechanism to govern the motor operation.

2. Apparatus as in claim 1 and wherein the circumferential conduit is disposed progressively around an extended length of convolution of a diameter substantially larger than that of the primary chamber.

3. Apparatus as in claim 1 and wherein the circumferential conduit is disposed progressively around an extended length of convolution of a diameter substantially larger than that of the primary chamber, and with an uptrend of flow towards the compartment.

4. Apparatus as in claim 1 and wherein the conduit is disposed with an uptrend toward the compartment and the two liquids meet with direct mutual contact in the compartment.

5. Apparatus as in claim 1 and wherein the compartment is annular and concentric with the governor axis, the two liquids being in annular streams therein.

6. Apparatus as in claim 1 and wherein the compartment is annular and concentric with the governor axis, the two liquids being in annular streams therein, in mutual contact, with the heavy liquid surrounding the light liquid during high speed operation, due to the centrifugal effect of the whirling motions thereof.

7. Motor governing apparatus adapted to act through suitable motor regulating mechanism for governing the speed of the motor under control of its rotary speed, such apparatus comprising a motor-rotated governor formed with a primary chamber containing a relatively heavy liquid subject to centrifugal force developing a liquid pressure varying with the motor speed, and with a secondary chamber containing a relatively light liquid and having a pressure-responsive instrument connected for operation of such regulating mechanism, and with passages communicating between said two chambers, said intercommunicating chambers and passages being as a whole closed against loss of liquid; said passages including an annular rotary compartment into which the heavy liquid extends from said primary chamber and the light liquid extends from said secondary chamber, the two liquids being in pressure-communicating relation in said compartment, and each liquid being in an annular whirling stream therein; whereby the heavy liquid pressure determined by the motor speed is communicated through the light liquid to the secondary chamber to act through said responsive instrument and regulating mechanism to govern the motor operation.

8. Apparatus as in claim 7 and wherein during operation the heavy and light liquids in the compartment are in the form of concentric whirling rings, the heavy surrounding the light liquid.

9. Apparatus as in claim 7 and wherein during operation the heavy and light liquids in the compartment are in the form of concentric whirling

rings, the heavy surrounding the light liquid, with the two in direct mutual contact.

10. Apparatus as in claim 7 and wherein during operation the heavy and light liquids in the compartment are in the form of concentric whirling rings, the heavy surrounding the light liquid, with the two in direct mutual contact, and the heavy entering the compartment with an uptrend.

11. Motor governing apparatus adapted to act through suitable motor regulating mechanism for governing the speed of the motor under control of its rotary speed, such apparatus comprising a motor-rotated governor formed with a primary chamber containing a relatively heavy liquid subject to centrifugal force developing a liquid pressure varying with the motor speed, and with a secondary chamber containing a relatively light liquid and having a pressure-responsive instrument connected for operation of such regulating mechanism, and with passages communicating between said two chambers, including a whirling annular compartment into which the heavy liquid extends with uptrend from said primary chamber and into which the light liquid extends from said secondary chamber with the two liquids in mutual contact in said compartment, whereby the heavy liquid pressure determined by the motor speed is communicated through the light liquid to the secondary chamber to act through said responsive instrument and regulating mechanism to govern the motor operation.

12. Apparatus as in claim 11 and wherein the annular compartment is of substantial axial or vertical dimension, thereby affording ample annular area of liquid contact surface for pressure communication from the heavy to the light liquid.

13. Apparatus as a claim 11 and wherein the pressure-responsive instrument consists of a flexible wall or diaphragm mounted at one side of the secondary chamber with oil-tight mounting and adapted to yield under pressure increase thereby affording mechanical movement for the actuation of the motor regulating mechanism.

14. A motor speed governor to act through suitable regulating mechanism to vary the speed

of the motor, said governor being operable under the combined control of the rotary speed of the motor and of its acceleration, positive or negative, and comprising a motor-rotated portion

5 formed with a central primary chamber containing a heavier liquid wherein centrifugal force develops a pressure varying with the motor speed, and with a central secondary chamber containing a lighter liquid, a pressure responsive instrument acted on by the lighter liquid and connected for operation of such motor regulating mechanism, and liquid passages communicating between the primary and secondary chambers including a compartment into which the heavier liquid extends from said primary chamber and the lighter liquid extends from said secondary chamber and wherein the two liquids are in pressure-communicating relation, and said passages including also an extended circumferential chamber between the primary chamber and said compartment and wherein angular accelerations due to changes of rotary speed cause modifications of the centrifugally produced pressure of the heavier liquid therein; whereby the pressure of the heavier liquid so determined by the combined actions of such centrifugal force and such angular accelerations is communicated through the lighter liquid to the secondary chamber to act through said responsive instrument and regulating mechanism to govern the motor operation, thereby, upon a sudden relative change of load, to afford an immediate correction of motor torque through the acceleration control and to maintain substantial balance of torque and avoid oscillation until the speed control gradually resets the motor speed.

15. A governor as in claim 14 and wherein the circumferential chamber is of substantially concentric annular form and of a diameter substantially greater than that of the central primary chamber; and wherein the compartment is of substantially concentric annular form and of substantial volume, and of a diameter between the diameters of said primary and circumferential chambers.

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