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GOVERNOR

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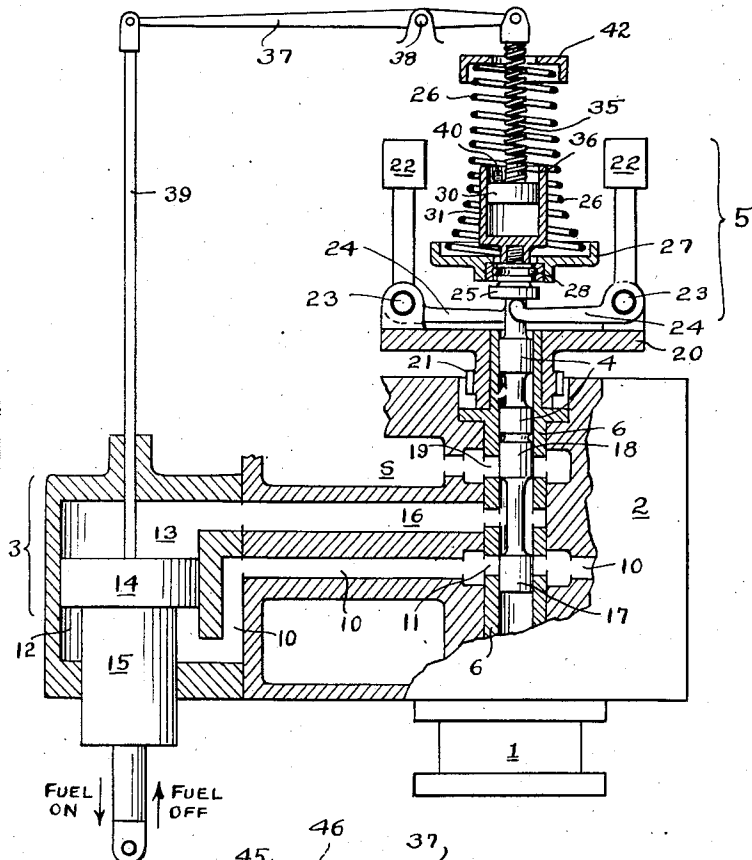


Fig-1

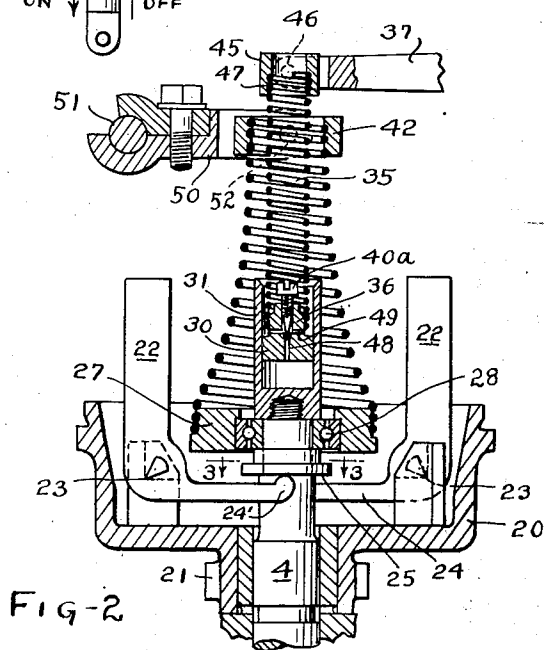


Fig-2

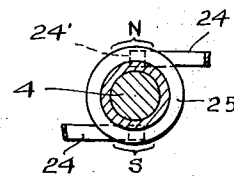


Fig-3

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2,378,558

GOVERNOR

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3 Claims. (Cl. 121-42)

This application is a continuation-in-part of my application Serial No. 350,255, filed August 3, 1940, now Patent No. 2,333,184, issued November 2, 1943, and discloses and claims certain features disclosed but not claimed in said patent and Patent No. 2,324,515 of July 20, 1943. The herein disclosed feature of effecting rotation of the pilot valve through the conjoint action of frictional and magnetic drag is set forth and claimed in my copending application Serial No. 591,211, filed April 30, 1945, which is a division of the present application. The invention relates to improvements in governors, particularly speed governors for prime movers.

The first above mentioned patent has as one of its principal objects that of increasing responsiveness of a governor incident to changes in conditions of the governed machine (e. g. load change on a governed prime mover) but without resulting in undue or excessive hunting. The present invention has the same general object; and more specific objects are: (a) to simplify the provision of a highly sensitive primary and secondary compensating means in an isochronous hydraulic relay governor, (b) provide a simple and effective means for adjusting the effects of secondary compensation; and (c) to provide an improved arrangement of receiving or actuated compensation piston and cylinder elements and securing relative rotation therebetween, particularly at low speed operation of the governor.

Other objects and features of the invention will become apparent from the following description relating to the accompanying drawing. The essential novel characteristics are summarized in the claims.

In the drawing, Fig. 1 is a more or less schematic vertical cross sectional view showing a form of governor mechanism and one form of compensating means (viz: according to my Patent No. 2,333,184); Fig. 2 is an enlarged central sectional view of a fly-ball head assembly including a pilot valve plunger and a somewhat modified form of compensating means operatively associated therewith; and Fig. 3 is a horizontal sectional detail view, taken as indicated at 3-3 on Fig. 2.

In Fig. 1 a hydraulic relay governor is shown diagrammatically comprising, generally, a base 1 adapted for connection with a machine, for instance an engine, to be governed; a power case 2, and a servo-motor 3. A pilot valve plunger 4 under the influence of a speed responsive mechanism 5 causes corrective operation of the servo-motor consequent upon changes in speed detected

by the mechanism 5, for regulating the governed machine. The pilot valve plunger 4, as shown, is generally cylindrical and operates in a fixed co-operating valve sleeve 6 in the power case, the sleeve being formed with lateral passages communicating with various ducts or spaces for hydraulic fluid which ducts and spaces will be specifically described below.

A governor drive shaft, as is usual with hydraulic relay speed governors, operates a positive pressure pump which in cooperation with an accumulator maintains substantially constant hydraulic pressure in a duct 10 in the power case, said duct communicating at all times with a port 11 of the fixed valve sleeve 6 and with a servo-motor cylinder space 12. The drive shaft, pump and accumulator are not shown herein but the arrangement thereof can be essentially the same as that of my Patent 2,219,229, issued October 22, 1940.

In the neutral or "balanced" position of the pilot valve plunger 4 hydraulic fluid is trapped in the upper cylinder space 13 of the servo-motor so that the servo-motor piston 14 is immobilized. The servo-motor piston is of the differential type, having a trunk portion 15 which reduces the effective area of the lower face of the piston 14. If fluid is vented from the cylinder space 13, the piston will be raised ("fuel off" movement) by constant pressure hydraulic fluid fed to the space 12 through the duct 10; and if said constant pressure fluid is fed to the larger face of the piston, as through the duct 16, the piston will move downwardly ("fuel on" movement).

The pilot valve plunger 4 has a land or plug portion 17, shown blocking the port 11, but, upon downward movement of the plunger, said plug releases constant pressure fluid to the upper (larger) servo-motor cylinder space 13 causing "fuel on" regulating movement of the servo-motor. Above a necked portion of the valve plunger is another land or plug portion 18 controlling a port 19 leading to a low pressure space or sump S for the purpose of dumping fluid from the servo-motor cylinder space 13 whenever the pilot valve plunger moves upwardly from the illustrated position, thus causing "fuel off" regulating movement of the servo-motor piston.

The speed responsive mechanism 5 is, as shown, a fly-ball head comprising a rotary body member 20 mounted for rotation on an upper reduced end of the fixed valve sleeve 6. The member 20 can be rotated by the governor drive shaft through a gear (not shown) connected with the drive shaft and meshing with pinion teeth 21 on

the ball head body. Fly balls are shown at 22 pivoted as at 23 to the body 20 and having ball arms 24 which bear upwardly against a circular thrust plate 25 fixed to an upper reduced portion of the pilot valve plunger 4. The centrifugal force of the fly-balls is normally balanced by an adjustable coiled speeder spring 26 coaxially of the valve plunger and having its lower end supported on a seat element 27 antifrictionally connected to the pilot valve plunger 4 as through a conventional ball bearing assembly 28.

By reason of the anti-friction bearing 28 and the fact that the fly-ball arms 24 continuously exert substantial upward pressure on the thrust plate 25 the contacting surfaces of the valve plunger 4 and valve sleeve 6 can be maintained continuously in relative rotation simply by the frictional force of the ball arm ends against the thrust plate, even though the latter is flat and smooth. The smooth surface is preferred because if indentations (i. e. notches) are provided in the lower surface of the thrust plate with the object of making a more positive driving connection between the ball arms and the plate, then it would be possible for the arm ends to leave the notches at times with resultant change in actual speed setting until the arm ends again entered the notches. The advantage of maintaining continuous rotation between the plunger type valve elements is that static friction and resulting sticking of the valve plunger are thereby eliminated, wherefore the valve plunger will always be ready to respond to the slightest change in speed capable of being detected by the fly-balls.

In hydraulic relay governors which are compensated during load (hence speed) change so as to avoid excessive hunting, and particularly in governors wherein compensation is effected through the intermediary of a hydraulically acting fluid system operative as a result of regulating servo-motor movement it had, prior to the invention of my said first mentioned patent, been known to provide for continuous relative rotation of the plunger pilot valve elements; but, so far as I know, it had not, in governors so compensated, been proposed further to eliminate occasional sluggishness of governor operation such as arises from sticking of the actuated or receiving compensation piston and cylinder elements. Thus isochronous hydraulic relay governors commercially available prior to the advent of my said invention were not, as I am informed, as sensitive to load change as they might have been and were frequently slow in re-establishing set speed after load change.

In the particular construction shown herein a servo-motor-movement-actuated compensation piston is shown at 30 operative in a working receiving compensation cylinder 31 attached to the upper or outer end of the pilot valve plunger 4 within the speeder spring 26. The cooperating compensation cylinder 31 is rigidly attached to the pilot valve plunger 4 so that it is continuously rotated with the fly-ball mechanism 5, whereas the compensation piston is restrained from rotation by the mechanism which causes the piston 30 to act compensatingly on the pilot valve plunger.

As shown in Fig. 1 the mechanism just mentioned comprises a coil spring 35 which is non-rotatively connected with the compensation piston 30 as by threads on a central part 36 of the piston, and extends upwardly out of the top end of the speeder spring 26 to a similar connection with a lever 37 pivoted as at 38 to the gov-

ernor casing and connected as by a rod 39 to the piston of the servo-motor. A lever of the class shown is used because the servo-motor, as shown, moves downwardly in response to downward movement of the pilot valve plunger in order to increase speed (i. e. supply more fuel) with respect to the governed machine; and, in order to effect primary compensation by means of force applied to the compensation piston 30, it is necessary to cause said force to be applied in a direction reverse to the movement of the pilot valve which initiates the described servo-motor movement. The force applied to the compensation piston 30 through the spring 35 is, of course, yielding irrespective of which direction the force is applied and the restraining influence on the pilot valve plunger (same as in my Patent 2,219,229) prevents overtravel of the pilot valve plunger during regulation-initiating action thereof following load change. The compensation piston 30 acts on the pilot valve plunger through whatever fluid medium is contained in the cylinder 31. Said fluid medium preferably is oil so that the coating surfaces of the piston and cylinder 30, 31 are continuously lubricated. Oil may be kept in the cylinder, regardless of depletion by having the entire piston and cylinder continuously submerged in sump supply.

Secondary compensation, necessary for isochronous operation, is obtained by a restricted passage of fluid from one side of the compensation piston 30 to the other, a threaded leak-off needle valve being indicated at 40 for adjusting the rate at which the forces stored in the compensation spring 35 will be dissipated. The needle valve is set according to the ability of the governed machine to respond to regulating operation following load change.

The operation of the mechanism, briefly, is as follows (e. g. as applied to the governing of an engine): As soon as the governor takes control the speeder spring is set for the desired speed, as by suitable vertical adjustment of a ring 42 or speeder plug at the top of the speeder spring. The rotating fly-balls then move the pilot valve plunger upwardly to balance the speeder spring force when the valve plunger is in the neutral position shown, thus stopping movement of the servo-motor at the necessary fuel-feeding position for that speed. Now, if the engine load is increased, the decelerated fly-balls lower the valve plunger, releasing fluid from the duct 10 into the chamber 13 and causing fuel-increasing movement of the servo-motor piston 14. As the servo-motor piston starts to descend (feed more fuel) the compensation spring 35 is stretched (primary compensation) thus tending to restrain the pilot valve against further downward movement and preventing over-regulation. As the set speed on part of the engine is restored, fluid leaks past the secondary compensation needle valve and relieves the stress in the stretched spring 35. Because of the continuous relative rotation of the pilot valve elements and compensation piston and cylinder elements the response to change in speed on part of the fly-balls is immediate, followed by proper correction; and there is no excessive hunting.

The governor works in a reverse manner upon decrease of load and consequent increase of engine speed, hydraulic fluid from the cylinder space 13 being vented to sump at port 19, causing raising movement of the servo-motor piston due to maintenance of constant pressure in the duct 10, and the compensation spring 35

is compressed instead of stretched for primary compensation. For secondary compensation, fluid moves from below the compensation piston 30 toward the sump past the needle valve 40.

Fig. 2 hereof shows the compensation mechanism substantially according to Fig. 1 but more in detail and with the secondary compensation needle valve 40a in a position rendering it accessible for adjustment during operation of the governor. The needle valve 40a, a screw as shown, is mounted axially of the compensation piston 30 in the extension 36 thereof to which the spring 35 is tightly threaded; and the connection of the spring 35 with the lever 37 is a sleeve 45 pivoted to a yoked end of the lever as at 46 and having internal threads 47 for tightly receiving the upper end of the spring 35. The lower tapered end of the needle valve 40a adjustably restricts an axial passage 48 communicating with the interior of the cylinder at its lower end and with a suitable lateral passage 49 in the piston leading (e. g.) to a negligible pressure area of the governor, for example, sump space within the upper end of the cylinder 31.

With the above described arrangement an operator has access to the head of the screw which constitutes the needle valve 40a through the sleeve 45 and compensation spring 35 as by means of a screw driver.

In Fig. 2 the ring 42 which constitutes the speeder plug is shown as pivoted to an arm 50 clamped to a speed adjusting shaft 51 suitable support for which would be provided in the governor casing as is usual. The pivot connection between the ring 42 and the adjusting arm 50 may comprise aligned pins on a yoked end of the arm (one pin indicated at 52).

It would, obviously, be possible to reverse the positions of the compensation piston and cylinder 30, 31 by having the piston attached directly to the valve plunger and the cylinder to the spring 35. In that event the needle valve 40 or 40a would be associated with the cylinder for making the valve accessible for adjustment. Also it will be evident that the spring 35 could be made to connect the pilot valve plunger and the cylinder 31, or, in case the elements 30 and 31 are reversed, then to connect said plunger and the piston.

In event the operating fluid contained between the compensating piston and cylinder 30, 31 is elastic then a rigid connection, as between the piston 30 and lever 37, can be used instead of a spring such as 35.

Figs. 2 and 3 also illustrate means for making certain of relative rotation of the mutually telescoping cylindrical parts 4, 6 and 30, 31 above described at very low speeds. During continuing low speed operation the pressure on the speeder spring 26 is sufficiently slacked off at times so that the ball arms 24 at finger portions 24' thereof bear relatively lightly against the thrust plate of ring 25, and if friction alone is depended upon to drive the pilot valve plunger and the cylinder 31 the driving force may fail due to inadequate friction. As pointed out above it is desirable that no positive or semi-positive driving connection be provided between the ball arms and thrust plate or ring, as by notching the ring. Notching tends to restrain free movement of the fly-balls and may result in disturbing the speed setting should the ball arm fingers ride out of the notches and remain in contact with the relatively raised smooth surface of the plate.

I have found that if the thrust plate or ring 25 is made permanently magnetic I can overcome likelihood of failure of the valve plunger and the cylinder 31 to be turned at low speeds notwithstanding the use of a perfectly smooth face for contact with the ball arm fingers. Preferably the thrust ring 25 is made of material such as cobalt magnetic steel or "Alnico" magnetic alloy or similar material which can be permanently magnetized to a relatively high degree. The thrust ring is preferably magnetized with opposite poles spaced circumferentially of the ring 180°. More than two poles obviously can be provided, e. g. alternating N. and S. The magnetic attraction between the ball arm fingers 24' and thrust ring 25 not only increases the driving friction due to the magnetic attraction but also results in appreciable circumferential magnetic driving pull as the ball arm fingers tend to leave the respective magnetic poles. This insures turning of the pilot valve plunger and cylinder 31 at all speeds of the ball head and does not impair the sensitiveness of the governor. The ball arms extend to and bear on the thrust ring at radially opposite regions of the thrust plate, see Fig. 3, the longitudinal axes of the ball arms 24 being offset from each other equal distances from the rotational axis of the thrust ring, so that when the fly-balls move inwardly and outwardly the ball arm fingers simply turn the valve plunger through contact with the thrust ring. In other words the fly-balls in responding to changes in speed do not have to slide on the thrust ring surface (as would be the case were the arms mutually aligned across the turning axis of the ring) but turn the ring instead.

I claim:

1. In a hydraulic relay governor, a pilot valve comprising a cylindrical valve plunger and complementary valve sleeve, said plunger being rotatable with respect to and projecting from one end of the sleeve, a hydraulic regulating servo-motor controlled by the valve, compensation piston and cylinder elements, one connected with the valve plunger at said projecting end so as to rotate with the valve plunger, and means including a non-rotating coil spring mechanically connecting the other compensation element to the servo-motor and acting to restrain said other compensation element against turning.

2. Mechanism according to claim 1 wherein the compensating element to which the coil spring is connected has a secondary compensation adjusting vent-inlet screw accessible for adjustment through the coil spring.

3. In the combination comprising a hydraulic relay speed governor of the type having a plunger type pilot valve, a regulating servo-motor controlled by the valve, speed responsive mechanism including a coiled speeder spring connected with a plunger element of the valve at one end of said spring for adjusting the speed of the governor and means or continuously rotating the plunger element; a compensation dash-pot, one element of which is corotatively operatively connected with an exposed end of said plunger element and the other element of which is non-rotatively connected with the servo-motor, said dash-pot being disposed at least partly within the coiled speeder spring.

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