May 9, 1950 A. F. SCHWENDNER 2,507,353

GOVERNOR-CONTROLLED SERVOMOTOR

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FIG. 1.

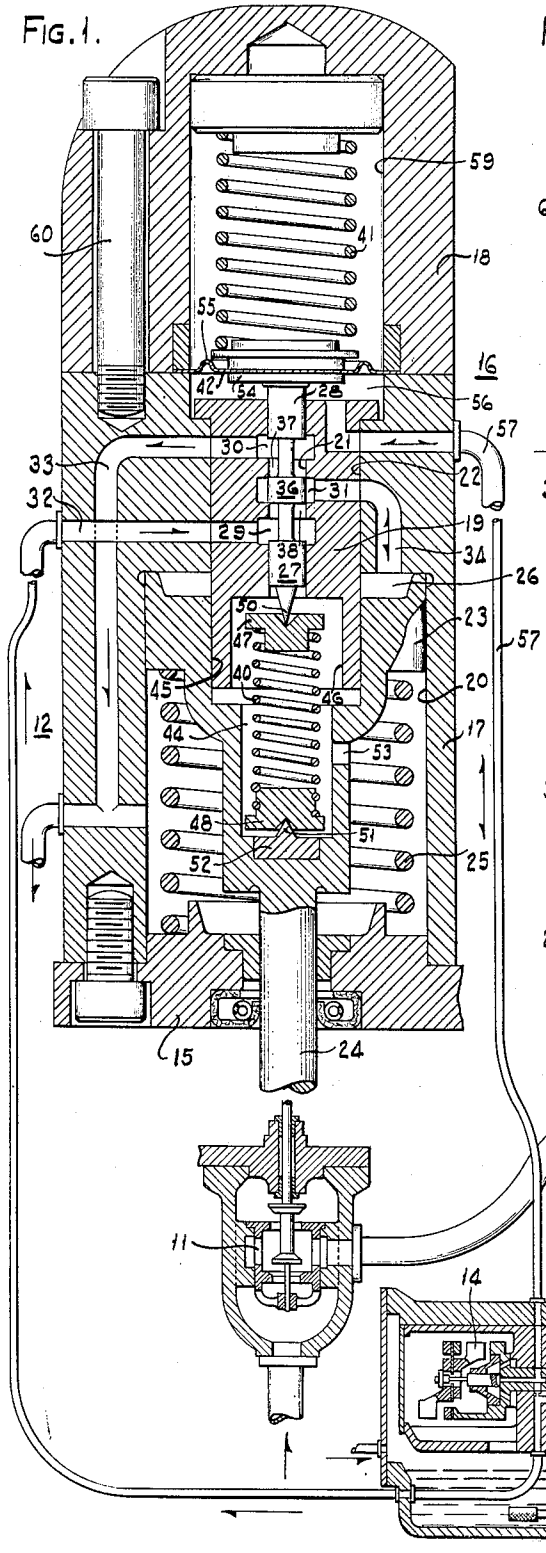
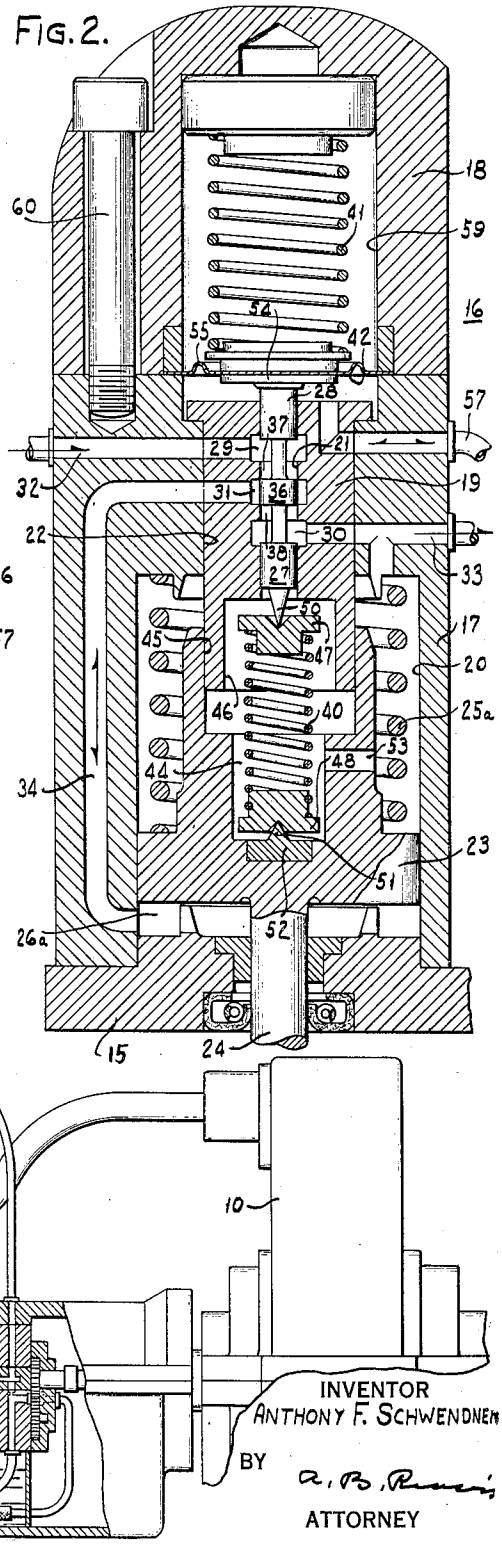


FIG. 2.



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GOVERNOR-CONTROLLED SERVOMOTOR

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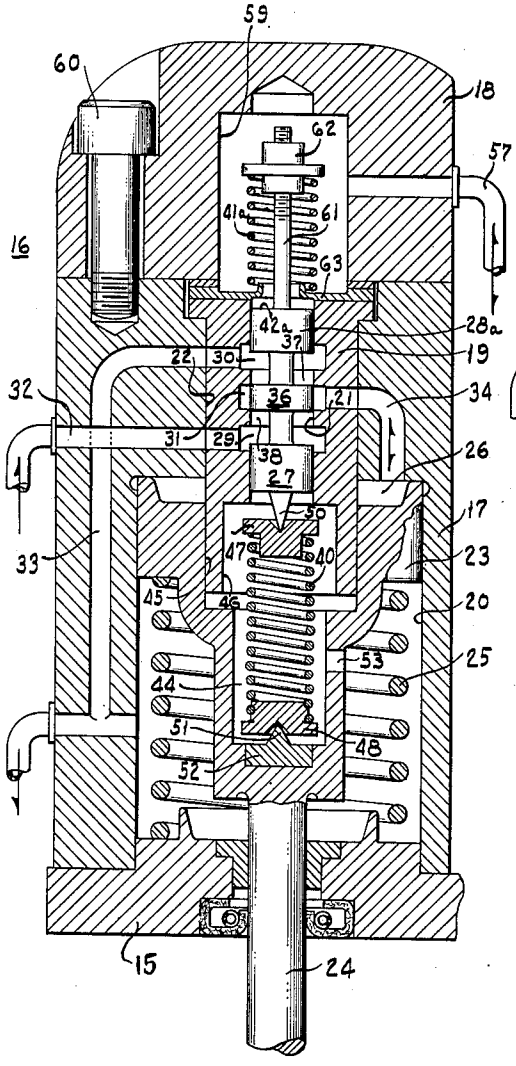


FIG. 3.

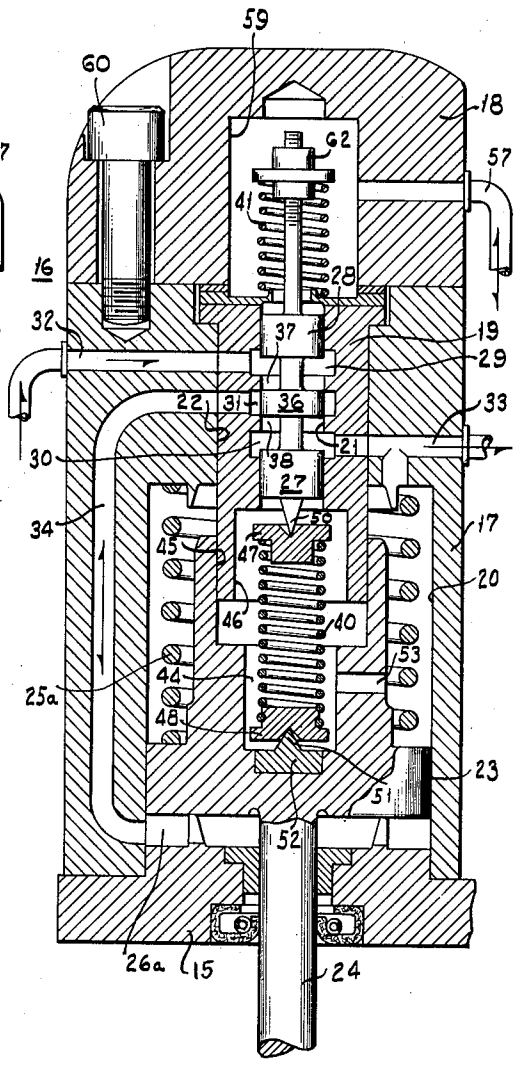


FIG. 4.

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GOVERNOR-CONTROLLED SERVOMOTOR

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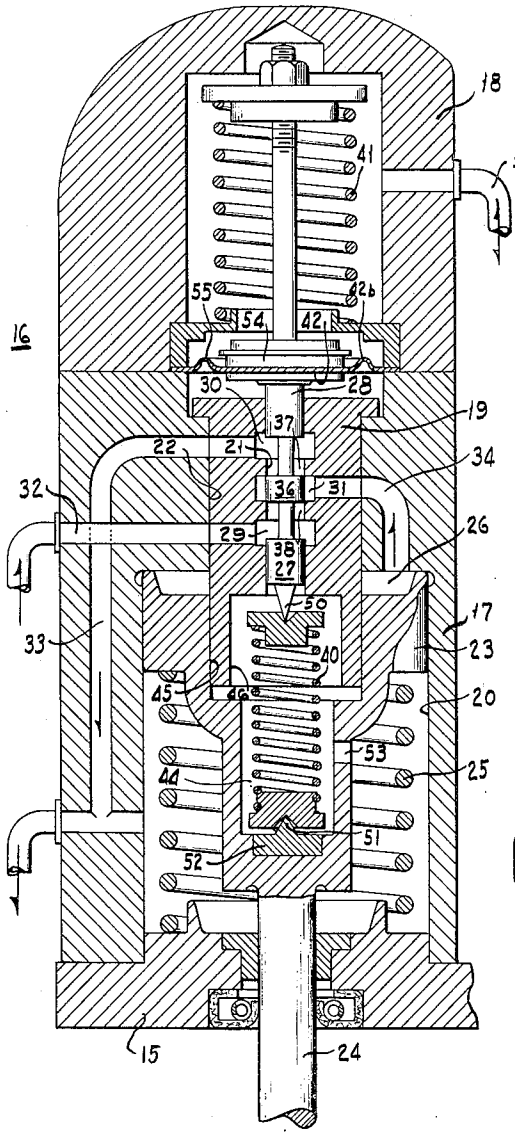


FIG. 5.

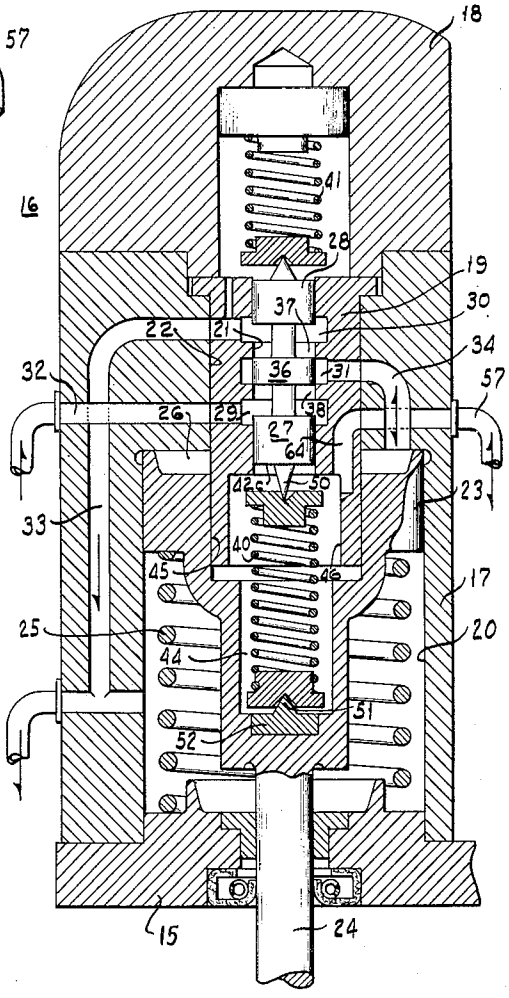


FIG. 6.

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GOVERNOR-CONTROLLED SERVOMOTOR

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FIG. 7.

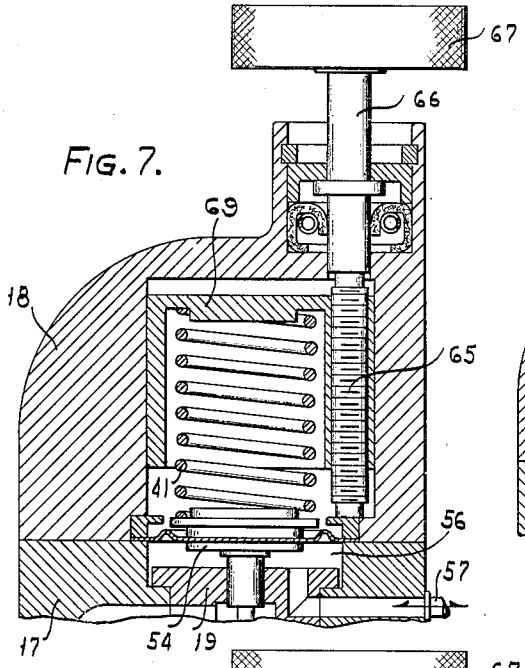


FIG. 8.

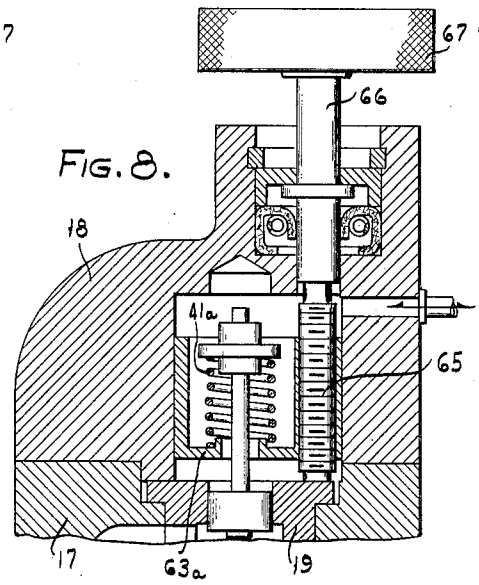


FIG. 9.

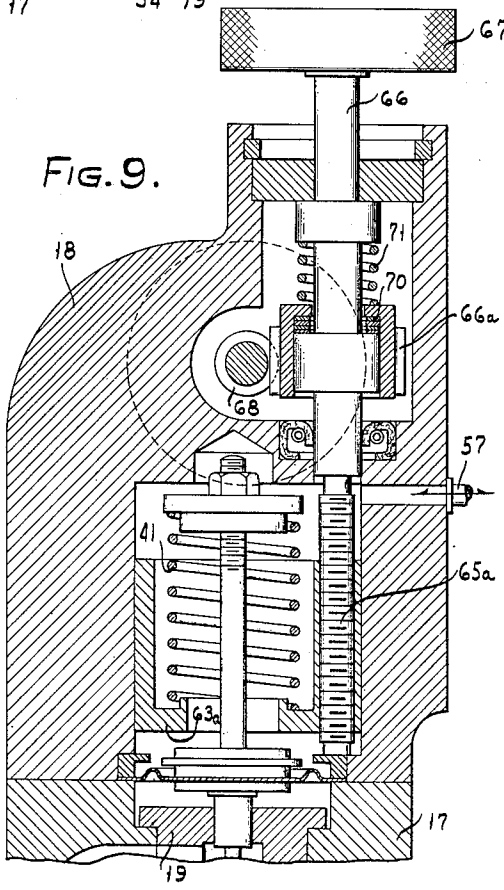
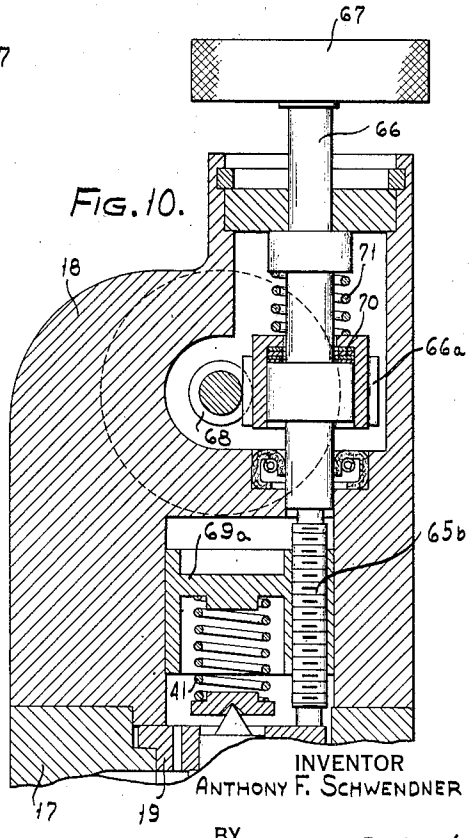


FIG. 10.



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Patented May 9, 1950 2,507,353

UNITED STATES PATENT OFFICE

2,507,353

GOVERNOR-CONTROLLED SERVOMOTOR

Anthony F. Schwendner, Ridley Park, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application April 10, 1947, Serial No. 740,625

2 Claims. (Cl. 121—42)

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The invention relates to a governor-controlled servo-motor for operating a prime mover motive fluid admission valve and it has for an object to provide means for amplifying a change in governing force or pressure and to use the amplified force or pressure to control the application of motive fluid to the servo-motor to effect displacement of its operated element or piston in proportion to the change in governing force or pressure.

A further object of the invention is to provide apparatus of the above character wherein the servo-motor operating piston is acted upon, at one side, by a spring and, at the other side, by motive fluid caused to be admitted or discharged by means of a relay positioned by the controlling or regulating liquid pressure exerting force in opposition to the resultant force of a pair of springs, including a follow-up spring interposed between the relay and the operating piston, so that, with change in controlling or regulating pressure and consequent disturbance of equilibrium of forces acting on the relay with the latter in lapping or cut-off position in relation to the operating cylinder, the operating piston moves to change the follow-up spring force until the latter balances the change in controlling or regulating pressure force with the relay restored to lapping or cut-off position.

In a fluid pressure governor, fluid pressure changes in response to speed change due to load change to vary the admission of motive fluid to the prime mover, and such fluid pressure is a regulating, controlling or governing pressure in that it is responsive to a prime mover characteristic, such as speed, to control the admission of motive fluid. The governor or controlling pressure may increase or decrease as the speed increases. Further, there are applications where a spring is depended upon to close the motive fluid control valve or valves in the event of oil failure; and there are other applications where the spring opens the control valve so that the prime mover can be started from a distance without oil pressure being available for starting. Applications may differ as to the sensitivity required. If a high sensitivity is not required, a large relay may be used and the controlling pressure may be applied directly to one end thereof. On the other hand, if high sensitivity is required, a diaphragm may be associated with the relay and the latter may be made of smaller diameter so that, for a given change in control pressure, the force of such pressure may be increased to the extent of the area increase so provided.

In accordance with the present invention, as

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the types of servo-motors satisfying the above conditions are similar to a very large extent and as a single type of follow-up is used, a servo-motor for one application can be changed for another application by changing a few parts and oil passages.

The follow-up system of the present invention provides, with fixed governor speed regulation and consequent fixed governor or control pressure change, for the operating mechanism following such change to a desired extent, that is, for a given governing force or pressure change, the operating piston may have a minimum or maximum stroke or any stroke in between. Also, with a fixed operating piston stroke, the regulation of the governing mechanism may be changed. The follow-up spring interposed between the relay and the operating piston can have its scale changed by the use of a longer or shorter spring nut, whereby the operating piston may be proportioned to a given governor or control pressure change.

Where the application is a constant speed one, with a speed range, that is, speed changer range, of not more than 20%, the speed changer may be mounted on the servo-motor to modify the action of the latter in relation to the governor. With wider speed ranges, the governor itself is provided with a speed changer.

Accordingly, a further object of the invention is to provide a servo-motor having an operating piston with a spring at one side and an expansible chamber at the other, together with a relay movable to establish communication of the expansible chamber with a supply of motive fluid under pressure or with a drain and to interrupt such communication, in response to force of controlling or governing liquid pressure acting in opposition to the resultant of forces applied to the relay by a pair of springs including a follow-up spring interposed between the operating piston and the relay, whereby, with disturbance of equilibrium of forces acting on the relay in interrupting position and due to control pressure change, the relay moves and movement of the operating piston pursuant to relay movement changes the force of the follow-up spring in a direction to move the relay toward interrupting position so that the force of the follow-up spring changes to balance the control pressure change with the relay restored to interrupting position.

A further object of the invention is to provide a servo-motor of the above character, wherein the relay is acted upon at opposite ends by a pair

of springs, including a follow-up spring between the relay and the operating piston.

Another object of the invention is to provide for adjustment of the scale of the follow-up spring in the relation just described.

A further object of the invention is to provide a servo-motor with a relay of the above character together with means for adjusting the spring of the pair of relay springs other than the follow-up spring.

A further object of the invention is to provide a servo-motor wherein the springs of the pair of relay springs exert forces on the relay in opposite directions and the pressure area subject to control pressure is arranged so that the control pressure force exerted thereby is in opposition to the force of the spring other than the follow-up spring.

A further object of the invention is to provide a servo-motor of the above character wherein the springs of the pair exert forces on the relay in the same direction and the force of controlling or governing liquid pressure is applied thereto in opposition to the springs.

Another object of the invention is to provide a servo-motor of the above character wherein the operating spring is arranged at the same side of the operating piston as the relay and the expansible chamber to which motive fluid is admitted and discharged under control of the relay is located at the other side of the piston, whereby the operating spring is effective to move the controlling valve for the prime mover in a closing direction.

A further object of the invention is to provide a servo-motor of the above character wherein the operating spring is arranged to exert its force in a direction to open the motive fluid valve.

A further object of the invention is to provide a servo-motor of the above character wherein the pair of relay springs exert their forces in the same direction so that the servo-motor may follow a governing or control pressure which decreases with increase in speed.

Still another object of the invention is to provide a servo-motor whose relay has a pair of springs acting thereon in opposite directions with the force of governing or liquid pressure acting thereon in a direction in opposition to the spring of the pair other than the follow-up spring to provide for a servo-motor arranged to follow a governor or control pressure which increases with increase in speed.

The foregoing and other objects are affected 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 sectional view showing one form of the improved servo-motor in diagrammatic relation to a suitable governor and prime mover;

Fig. 2 is a view showing a modified form of the servo-motor illustrated in Fig. 1;

Fig. 3 shows another embodiment of the servo-motor arranged to follow a controlling or regulating pressure which decreases with increase in speed;

Fig. 4 illustrates a modification of the embodiment shown in Fig. 3;

Fig. 5 shows a further embodiment of the servo-motor arranged to follow a controlling or regulating pressure which decreases with increase in speed;

Fig. 6 shows an embodiment of the invention which is similar to Fig. 1 but in which the regulating or governing pressure is applied to the relay in a different manner;

Figs. 7 and 8 are sectional detail views showing manual speed changers for the forms of the inventions shown in Figs. 1 and 3, respectively; and

Figs. 9 and 10 are sectional detail views of combined manual and motor-operated speed changers suitable for the forms of the invention shown in Figs. 5 and 6, respectively.

Referring to the drawings more in detail, in Fig. 1, there is diagrammatically shown a turbine **10** having an admission valve **11** operated by the pressure-responsive servo-motor mechanism, at **12**. The turbine drives a governor **14** operative to provide regulating, controlling or governing pressure which changes in response to speed change, the governing or controlling liquid pressure so provided being supplied to the servo-motor.

The direction of change of the regulating or controlling pressure may be the same as or opposite to that of speed change, the servo-motor having its pair of relay springs including the follow-up spring, acting in opposite directions with the force of liquid pressure acting against the differential spring force where the servo-motor follows a control pressure which increases with increase in speed and having both springs acting on the relay in the same direction and in opposition to the controlling or regulating liquid pressure where the servo-motor is called upon to follow a controlling or regulating pressure which decreases with increase in speed, Figs. 1, 2, 4 and 6 being of the first type and Figs. 3 and 5 being of the second type.

In the drawings, there is shown a body construction, at **16**, comprising a body member **17**, a cap member **18**, a plug **19**, and a head or bottom cover **15**.

The body member is provided with an operating cylinder **20** and a relay valve cylinder **21** coaxial therewith. Preferably, where, as shown, the body structure includes the plug **19**, the latter is formed with the relay valve cylinder and the body member has a bore **22** within which the plug is fixed.

An operating piston **23** is arranged in the operating cylinder **20** and it has a rod **24** extending through the head or bottom cover **15** and connected to the turbine admission valve **11**.

The operating spring **25** acts on one side of the operating piston **23** and the latter cooperates with operating cylinder **20** to provide an expansible chamber **26** at the side of the piston opposite to the spring.

A relay, at **27**, comprising the piston valve **28** and the valve cylinder **21**, controls the admission of fluid under pressure to the expansible chamber **26** to move the operating piston against the opposition of the operating spring **25** and the discharge of liquid from the chamber to provide for movement of the operating piston by the spring.

The relay cylinder **21** has a pressure port **29**, a drain port **30**, and an operating port **31**. The body structure, at **16**, is formed with a motive fluid supply passage **32** communicating with the pressure port **29**, a drain passage **33** communicating with the drain port **30**, and an operating passage **34** communicating with the operating port **31** and with the expansible chamber **26**.

The relay piston valve **28** has a land **36** separating spaces **37** and **38** continuously open to the drain and pressure ports **30** and **29**.

The relay piston valve is positioned in response to the resultant of forces of a pair of springs opposed by the force of governor or controlling liquid pressure applied to a pressure area formed on means movable with the relay piston valve. The springs include a scale spring 40 interposed between the lower end of the piston valve 28 and the operating piston 23 and a spring 41 cooperating with the upper end of the relay piston valve. The pressure area 42 is formed on means movable with the piston valve 28 and it is acted upon by liquid under controlling governor pressure.

From the structure described, it will be apparent that the servo-motor operates in response to fluid pressure acting against a spring. The spring acts in a direction to open the admission valve 11 in Figs. 1, 3, 5 and 6 and to close such valve in Figs. 2 and 4.

The governor, as more particularly disclosed in my application Serial No. 568,436, filed December 16, 1944, now Patent No. 2,467,445, may operate to provide a controlling pressure which varies directly or inversely as a function of speed. In Fig. 1, there is shown the direct type where speed and pressure changes occur in the same direction.

The direct and inverse governing arrangements each may be used to control either the type of servo-motor in which pressure operation effects closing movement of the admission valve or in which closing is effected by the spring. Increase in speed is accompanied by increase in controlling or governing pressure for pressure operation (Figs. 1 and 6) or for spring operation (Fig. 2) of the servo-motor to move the admission valve in a closing direction; and increase in speed is accompanied by decrease in controlling pressure for spring operation (Fig. 4) or for pressure operation (Fig. 5) of the servo-motor to move the admission valve in a closing direction.

In all forms of the invention, when the forces acting on the servo-motor relay are in equilibrium, the relay piston valve is in neutral or cut-off position with its land 36 lapping the operating port. A change in governing pressure resulting from a change in speed pursuant to a change in load results in disturbance of the equilibrium condition of forces acting on the relay, in consequence of which the relay piston valve moves to place the expansible chamber of the servo-motor operating cylinder in communication with the pressure port or with the drain port to bring about movement of the operating piston and change in force of the scale spring 40 in a direction to move the relay piston valve toward lapping position until the change in scale spring force balances the change in governing pressure force, at which time the piston valve is restored to lapping position.

In Fig. 1, the operating spring 25 is arranged at the side of the operating piston 23 remote from the relay and the operating passage 34 communicates with the expansible chamber 26 at the relay side of the operating piston. The pair of springs 40 and 41 act in opposite directions on the relay piston and the pressure area 42 applies governing or control pressure force, which, with the force of the scale spring 40 in the same direction, act in opposition to the force of the upper spring 41 with the result that the servo-motor follows a control or governing pressure which increases as the speed increases. With this arrangement, it is obvious that the scale of the spring 41 must be larger than that of the spring 40 in that it is called upon to operate against both the spring 40 and the control pressure force.

To accommodate the scale spring 40 and to aid in guiding the operating piston 23, the latter is formed with a central hollow space 44 including the cylinder bore 45 with which the lower end of the plug 19 has a piston fit. The lower end of the plug is counterbored at 46 in coaxial relation with the relay valve cylinder or bore.

The scale spring 40 has its ends engageable with upper and lower abutments 47 and 48 and the latter have point bearing relation with respect to the lower pointed end 50 of the relay piston valve and with respect to the upwardly-directed pointed portion 51 of the block 52 seated in the bottom of the cavity 44. The operating piston cavity 44 and the plug counterbore 46, therefore, provide space for the accommodation of the scale spring and its upper end lower abutments.

Preferably, the operating piston is formed with an opening 53 so that oil leaking into the central cavity may drain therefrom.

In Fig. 1, the pressure area 42 is provided by an abutment 54 and a diaphragm 55 connecting the abutment to the body structure. At its lower side, the abutment has thrust relation with the upper end of the relay piston valve and it abuts the lower end of the spring 41.

As the pressure area 42 is exposed to the pressure in the chamber 56 communicating with the governing or control liquid pressure passage 57, it will be apparent that a change in controlling or governing liquid pressure and consequent movement of the abutment and diaphragm, results in change in thrust pressure exerted by the upper spring 41 on the piston valve. Increase in controlling liquid pressure acting on the abutment 54 against the force of spring 41 results in movement of the abutment and of the relay piston valve to place the operating cylinder expansible chamber 26 in communication with the pressure supply passage 32, in consequence of which the operating piston 23 moves downwardy, reducing the force of the scale spring 40 acting on the lower end of the relay piston valve, until the relay is restored to lapping or neutral position with the spring and fluid pressure forces acting thereon balanced.

On the other hand, if the controlling or governing pressure is reduced, the contrary operation takes place. As the liquid pressure force is diminished, the spring 41 becomes increasingly effective to exert downward force on the relay piston valve, whereby the latter is moved downwardly to place the operating cylinder expansible chamber 26 in communication with the drain passage 33, whereupon the operating spring moves the operating piston upwardly. However, as such piston is moved upwardly, the force of the spring 40 is increased to move the piston valve 28 toward lapping position, such return movemenut of the relay piston valve and movement of the operating piston continuing until the piston valve land 36 is restored to lapping position with the change in force of the scale spring balancing the change in liquid pressure force applied to the pressure area 42.

To provide for change in effective length of the scale spring and, therefore, scale of the latter, the lower abutment 48 preferably takes the form of a nut which may be adjusted with respect to the spring convolutions.

Preferably, the upper spring 41 of the relay is housed in a cavity 59 formed in the cap member 18 and the cap member 18 and body member 17 have joint surfaces arranged substantially at the upper end of the relay, the cap member being

secured to the body member by means of screws or bolts 60, one of which is shown.

In Fig. 1, an increase in load results in a slight reduction in speed, causing the governor to increase the governor or controlling pressure, in consequence of which the piston 23 is operated to open the admission valve wider to suit the increase in load.

Fig. 2 differs from Fig. 1 in that the operating spring 25a is arranged at the relay side of the operating piston and the operating passage 34 communicates with an expansible chamber 26a at the side of the operating piston remote from the relay. With this arrangement, an increase in governing or controlling pressure pursuant to decrease in load results in spring operation of the servo-motor to move the admission valve in a closing direction and a decrease in such governing or control pressure incident to load increase results in pressure operation of the servo-motor to move the admission valve in an opening direction.

In Fig. 3, the scale spring 40 and the upper spring 41a exert force on the relay piston valve 28a in the same direction and the resultant of the forces thereof is opposed by the force of liquid pressure applied to the pressure area 42a provided by the upper end of the relay piston valve 28a, governing or liquid pressure being supplied for action on the pressure area 42a by means of the passage 57 connected to the governor.

Preferably, as shown, the relay piston valve 28a has a stem 61 extending upwardly through the spring 41a and an abutment 62 has a threaded connection with respect to the upper end of the stem. The lower end of the spring bears on a retainer structure 63 fixed in relation to the body structure. Therefore, the upwardly acting force exerted on the relay piston valve by the spring 41a may be varied by suitable adjustment of the abutment 62. Also, as already described, the scale of the spring 40 may be varied by adjustment of its lower end with respect to the lower abutment 48. In this form of the invention, the servo-motor is controlled by a controlling pressure which changes reversely in relation to speed change.

Fig. 4 is similar in most respects to Fig. 3, except for operation of the servo-motor. Instead of the servo-motor being pressure-operated to move the admission valve in a closing direction and spring-operated to move the latter in an opening direction, as in Fig. 3, in Fig. 4, the reverse is true, the admission valve being spring-closed and pressure-opened.

Fig. 5 shows an arrangement which is structurally and functionally similar to Fig. 3, the only difference being the provision of means providing a larger piston area 42b acted on by controlling liquid pressure to apply downwardly-acting force to the relay. As compared to Fig. 3, the provision of a larger pressure area 42b is made possible by the use of an abutment and a diaphragm, the larger area providing, for a given change in governing pressure, for a larger fluid pressure force applied to the relay piston valve, whereby the sensitivity of the arrangement shown in Fig. 5 is a greater than that shown in Fig. 3 in which the piston area is limited to that provided by the upper end of the relay piston valve.

Fig. 6 is similar to Fig. 1 in structure and in operation except that, instead of the pressure area 42 effective at the upper end of the relay piston valve in Fig. 1, in Fig. 6, a passage 64 is connected to the control pressure supply passage 57 and communicates with the operating piston central cavity 44 so that such pressure acts upwardly on the pressure area 42c provided by the lower end of the relay piston valve. Here again, the pair of relay springs 40 and 41 act in opposed relation on the relay piston valve and the force of governing liquid pressure acts upwardly thereon in opposition to the force of the upper spring 41.

Figs. 7, 8, 9 and 10 show speed changers for different embodiments of the invention already described.

Fig. 7 shows a hand-operated speed changer for the embodiment shown in Fig. 1, the speed changer comprising a screw 65 carried by a shaft 66 rotatably mounted on the cap member and having a handwheel 67 attached to its outer end. The screw 65 meshes with a threaded opening formed in an abutment 69 for the upper end of the spring 41. By adjustment of the position of the abutment 69 with respect to the body structure, the force of the spring 41 is varied in relation to the governing liquid pressure force, increase in spring compression calling for a larger governing liquid pressure force for the same position of the abutment 54 and vice versa.

Fig. 8 shows a speed changer similar in principle to that shown in Fig. 7 but modified to suit the embodiment of servo-motor illustrated in Fig. 3. In this form, instead of the lower end of the retainer or abutment 63 for the spring 41a being fixed, as in Fig. 3, the abutment 63a is adjustable by means of the screw 65, upward movement of the abutment 63a by operation of the screw resulting in increase in upward force of the spring 41a and therefore increase in the required governing pressure required to give a liquid pressure force to balance the increased spring force.

In Fig. 9, there is shown a motor-operated type of speed changer for the form of the invention illustrated in Fig. 5. Instead of the lower end of the upper relay spring bearing against the fixed abutment, as in Fig. 5, in Fig. 9, the abutment 63a is engageable with a screw 65a having a worm gear 68a meshing with a motor-operated worm 68.

In Fig. 10, there is shown a motor-operated speed changer suitable for the form of the invention shown in Fig. 6. The upper end of the spring 41 is engaged by the abutment 69a movable with respect to the cap member by means of the motor-operated screw 65b having worm gear 68a operatively connected to the motor 68.

In addition to motor operation of the screws 65a and 65b in Figs. 9 and 10, it will be noted that these screws may also be manually operated. To this end, the worm gears 68a instead of being fixedly connected to the screw shafts, are connected thereto by slip friction clutches 70 wherein the extent of friction is determined by the load spring 71. Therefore, the handwheel 67 of the screw shaft in either Figs. 9 or 10 may be grasped and the screw turned, the clutch preventing the worm gear from slipping relative to the screw shaft.

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 changes and modifications without departing from the spirit thereof.

What I claim is:

1. In a servo-motor for controlling the admission of motive fluid to a prime mover in response to liquid under governing pressure varying as

a function of speed, a body construction comprising a body member having an operating cylinder opening through its lower end and a bore coaxial with the cylinder, said bore having its lower end opening into the operating cylinder and having its upper end opening through the upper end of the body member, a bottom head member detachably connected to the body member and closing the lower end of the operating cylinder, a cap member detachably connected to the upper end of the body member and provided with a bore, and a plug member filling the body member bore; said plug member having a relay cylinder coaxial with the body member bore and the operating cylinder; said body member and plug member having operating cylinder, pressure supply and exhaust passages terminating in operating cylinder, pressure supply and exhaust ports for the relay cylinder; an operating piston in the operating cylinder and dividing the latter into spring and pressure spaces with the pressure space communicating with said operating cylinder passage; an operating spring in the spring space and exerting force on the operating piston in opposition to that of pressure of liquid of the operating cylinder passage; a relay piston in the relay cylinder and movable from a neutral position just lapping the operating cylinder port to place the latter in communication either with the pressure supply port or with the exhaust port depending upon the direction of movement; means including a pressure area and a pair of upper and lower springs for applying forces in opposite directions to the relay piston; the upper relay spring being located in the cap member bore and having its ends abutting the body construction and the relay piston and the lower relay spring having its ends abutting the relay and the operating pistons; means for applying liquid under governing pressure to the pressure area so that, with the relay piston in neutral position and the forces acting thereon in equilibrium, a change in speed results in disturbance of such equilibrium and consequent movement of the operating piston to change the admission of motive fluid to the prime mover until the force of said lower relay spring is changed sufficiently to restore the forces acting on the relay piston to equilibrium with the latter restored to neutral position.

2. Apparatus as claimed in claim 1 with a speed changer carried by the cap member and operative to change the loading of the upper relay spring.

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