April 4, 1939. A. MAAS 2,153,381

HYDRAULIC CONTROL MECHANISM

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Fig. 1.

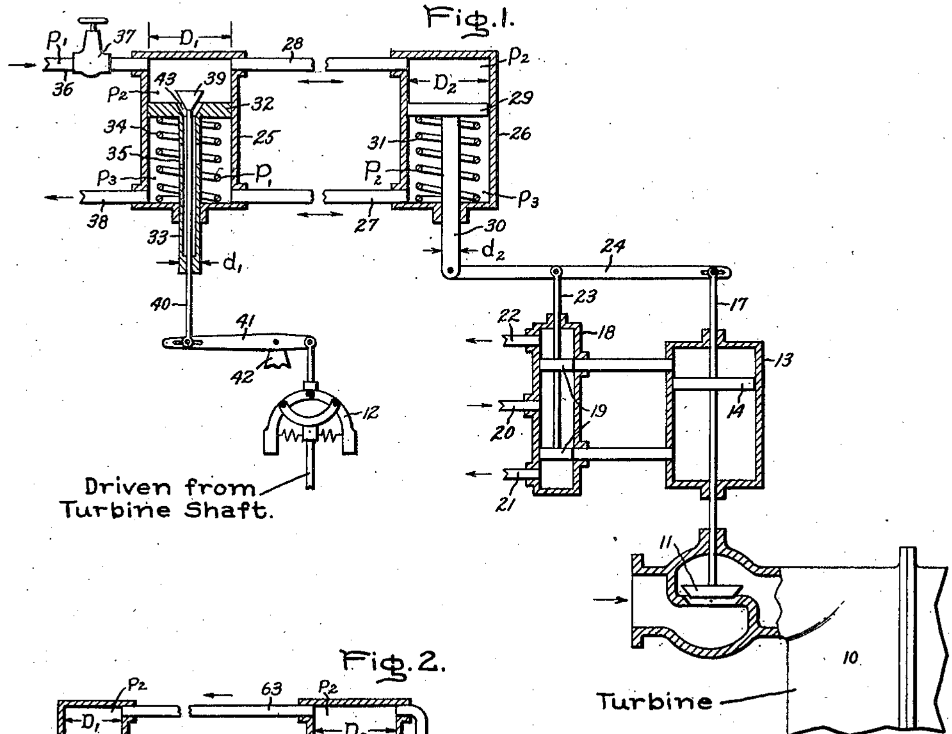

Fig. 2.

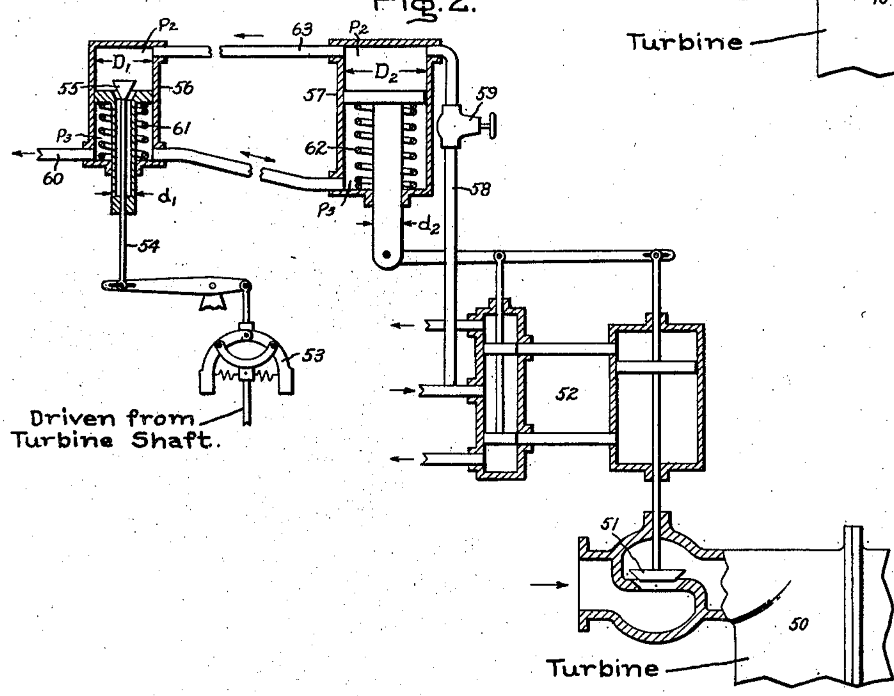

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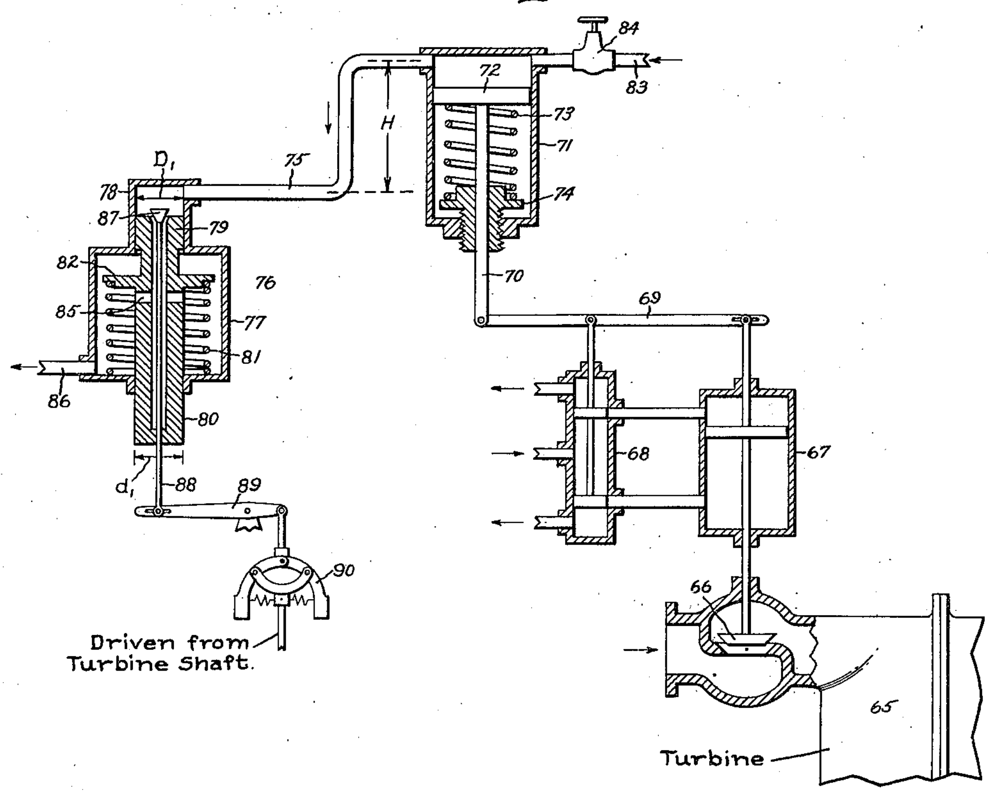
Fig. 3.



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2,153,381

HYDRAULIC CONTROL MECHANISM

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7 Claims. (Cl. 121—42)

The present invention relates to hydraulic control mechanisms and more specifically to the type of mechanisms for remotely controlling a prime mover or like engine by means including a speed governor or other controlling element responsive to changes of a condition of the engine which speed governor or element is arranged at a considerable distance from the controlled element. Heretofore it has been difficult accurately to control the valves of turbines or like elements by means of hydraulic remote control mechanisms due to inaccuracies caused by changes of the viscosity of the operating medium such as oil which made it impossible to attain a linear response between the stroke of a power piston and the change in speed or like condition.

The general object of my invention is to provide an improved construction and arrangement of hydraulic remote control mechanisms whereby accurate control is attained and the amount of operating fluid for the mechanism is considerably reduced.

For a consideration of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto in connection with the accompanying drawings.

In the drawings, Fig. 1 illustrates a hydraulic remote control mechanism embodying my invention, and Figs. 2 and 3 illustrate modifications of my invention.

The arrangement of Fig. 1 comprises an elastic fluid turbine **10** with a controlled element, in the present instance an inlet valve **11**, for controlling the admission of elastic fluid thereto. The control mechanism for moving the valve **11** comprises a controlling element, in the present instance a speed governor **12**, located at a considerable distance from the inlet or admission valve **11** and a hydraulic motor **13** with a piston **14** secured to a stem **17** which latter forms in substance an extension of the stem of the admission valve **11**. The supply and discharge of operating fluid to and from the motor **13** is controlled by a pilot valve **18** which has valve heads **19**, an inlet conduit **20** and drain conduits **21** and **22**. The valve heads **19** are secured to a stem **23** which in turn is pivotally connected to an intermediate point of a floating lever **24** pivotally connected at its right-hand end to the piston stem **17**. Movement of the speed governor **12** is transmitted to the floating lever **24** by means including two hydraulic cylinders, a cylinder **25** disposed near the governor **12** and a cylinder **26** disposed near the lever **24** and connected to the cylinder **25** by conduits **27** and **28**. The cylinder **26** contains a power piston **29** secured to a stem **30** which at its lower end is pivotally connected to the left-hand end of the floating lever **24**. The piston **29** is biased in upward direction by a spring **31** contained in the cylinder **26** and surrounding the piston stem **30**.

The cylinder **25** contains a piston **32** which is secured to the upper end of a hollow piston stem **33** and biased upwardly by a spring **34** contained in the cylinder **25** and surrounding the stem **33**. The stem **33** has lateral openings **35** forming part of a passage for operating fluid supplied to the upper portion of the cylinder through an inlet conduit **36** having a valve **37** and discharged from the lower portion of the cylinder through a drain conduit **38**. The operating fluid on its path from the space above the piston **32** to the space below the piston **32** flows through the passage formed by the hollow stem **33** and the aforementioned lateral openings **35**. The flow through said passage is controlled by means of a suitable valve such as a needle valve **39** in cooperative relation with a valve seat formed in the upper surface of the piston **32** and secured to a stem **40** concentrically disposed within the hollow stem **33** and projecting through the lower end thereof. The stem **40** is pivotally connected to the left-hand end of a lever **41** which has an intermediate point supported on a fulcrum **42** and a right-hand end connected to the speed governor **12**.

With this arrangement a change in speed of the turbine to be controlled causes movement of the speed governor which in turn positions the valve **39**. This changes the restriction or passage **43** formed between the latter and its valve seat. More specifically, an increase in turbine speed causes outward movement of the fly weights of the governor **12** whereby the right-hand end of the lever **41** is moved downward thus effecting upward or opening movement of the valve **39**. This increases the passage **43** and thus reduces the restriction to flow of operating fluid from the space above the piston **32** to the space below said piston **32** resulting in a drop in pressure of the fluid contained in the upper portion of the cylinder **25** and also in the upper space of the other cylinder **26**. This causes upward movement of the piston **29** by the action of the spring **31** and a similar upward movement of the pilot valve heads **19** to permit the supply of operating fluid from the conduit **20** to the upper space in the hydraulic motor **13** and the discharge of operating fluid from the lower space of the hydraulic motor **13** through the pilot valve drain conduit **21**. The piston **14** of the hydraulic motor **13** under such condition is moved downward and effects closing movement of the admission valve 11. This movement continues until the normal operating speed of the turbine is established. Vice versa, during a decrease in turbine speed the valve 39 is moved downward effecting similar movements of the other elements as described above, but in opposite direction to effect opening movement of the turbine admission valve 11.

Whenever the valve 39 is moved downward and thus the pressure above the piston 32 is increased, the latter is also moved downward by the increased pressure in the upper cylinder portion against the pressure of the spring 34. Thus the piston 32 always follows the movement of the valve 39 and for this reason said piston 32 may be termed a follow-up piston. The cylinder 25 with its piston 32 may be termed a pressure varying device because it serves to vary the fluid pressure in response to changes of operating condition. The other cylinder 26 together with its piston 29 may be termed a pressure responsive device in that one of its elements, the piston 29, is moved in response to pressure changes. In these arrangements, it is of primary importance that the movement of the pressure responsive device is always either equal or proportional to the movement of the pressure varying device. This is accomplished in accordance with my invention by properly dimensioning the two devices 25 and 26. In the present instance, the inner diameters D_1 and D_2 of the cylinders 25 and 26 are alike. Likewise the outer diameter d_1 of the piston stem 33 is equal to the outer diameter d_2 of the piston stem 30.

Let us assume that the fluid pressure in the supply conduit 36 be p_1 which pressure is throttled down by the valve 37 to effect a pressure p_2 above the piston 32 in the cylinder 25. The pressure then in the space above the piston 29 is also p_2. The pressures in the spaces below the pistons 32 and 29 are p_3. Under such condition the pressure varying piston 32 is held in position as long as equilibrium exists between the force exerted by pressure p_2 on its upper surface and the force exerted by the pressures p_3 and P_1 acting on the lower surface of the piston, the force P_1 representing the compression of the spring 34. Likewise, the piston 29 remains in position as long as balance exists between the force exerted by the pressure p_2 on its outer surface and the forces exerted by the pressures p_3 and P_2 on its lower surface. P_2 represents the compression of the spring 31. In the present instance with the pressures p_2 and p_3 alike in the two cylinders P_1 must be equal to P_2. In an arrangement of this kind, the strokes of the pressure varying or follow-up piston 32 and the power piston or pressure responsive piston 29 during any load change will be alike or at least proportional. In other words, the pressure curve of the fluid contained in the conduit 28 connecting the two cylinders 25 and 26 must have a linear course. Changes of viscosity of the operating fluid then can have no disadvantageous effect on the mechanism. An arrangement of this kind, however, necessitates the circulation of a comparatively considerable amount of operating fluid such as oil because both cylinders are of the same size and have to be filled and drained within a short period of time to permit quick opening and closing of the turbine admission valve.

Fig. 2 shows an arrangement in which the amount of operating fluid is considerably reduced and at the same time the periods of starting and shutting down the turbine kept at a minimum. More specifically, the arrangement includes a turbine 50 with an admission valve 51 which is controlled by a mechanism comprising a hydraulic motor and pilot valve 52 corresponding to the hydraulic motor 13 and the pilot valve 19 of the arrangement in Fig. 1. In addition, the mechanism comprises a speed governor 53 driven from the turbine shaft and connected to a stem 54 of a needle valve 55 corresponding to the stem 40 and the valve 39 of Fig. 1 and forming a part of a pressure varying device 56. The device 56 is connected to a pressure responsive device 57 corresponding to the device 26 of Fig. 1. The arrangements of Fig. 1 and Fig. 2 are alike with the following exceptions. The device 56 is considerably smaller than the device 57 and, whereas in Fig. 1 operating fluid is directly supplied to the cylinder 25, in the arrangement of Fig. 2 the operating fluid is supplied by a conduit 58 with the valve 59 to the device 57. The conduit 58 is connected to the inlet conduit for the hydraulic motor and pilot valve 52 whereby both the hydraulic motor and the devices 56 and 57 are connected to the same source of fluid under pressure. The pressure varying device 56 has an outlet or drain conduit 60. The inner diameter D_1 of the device 56 is smaller than the diameter D_2 of the device 57. Also the diameter d_1 of the piston stem of the device 56 is smaller than the diameter d_2 of the piston stem of device 57. In an arrangement of this kind, the strokes of the pistons of the devices 56 and 57 are no longer alike. In order, however, to maintain proportionality of movements between the two pistons, the ratio of the compressions of the springs 61 and 62 of the devices 56 and 57 respectively must meet the following condition:

$$\frac{P_1}{P_2}=\frac{D_1^2(p_2-p_3)+d_1^2p_3}{D_2^2(p_2-p_3)-d_2^2p_3}$$

The pressures p_2, p_3 are the fluid pressures in the upper and lower space respectively of the devices 56 and 57. The formula applies to both arrangements in Figs. 1 and 2.

The operation of the mechanism of Fig. 2 is the same as that described above in connection with Fig. 1. However, while the fluid in the conduits 27 and 28 connecting the two devices in Fig. 1 may flow in either direction, in the arrangement of Fig. 2, the flow of fluid in the conduit 63 connecting the upper spaces of the two devices is unidirectional because in this arrangement the operating fluid is supplied to the device 57 and not to the device 56.

The arrangement of Fig. 3 comprises a turbine 65 with an inlet valve 66 which is connected to a hydraulic motor 67 controlled by a pilot valve 68 having stems connected to a floating lever 69 corresponding to the lever 24 of Fig. 1. The left-hand end of the floating lever 69 is connected to the lower end of a piston stem 70 forming part of a pressure responsive device 71. The device 71 in addition includes a piston 72 secured to the upper end of the stem 70 and biased upwardly by a compression spring 73 surrounding the stem 70 and bearing at its upper end against the piston 72 and at its lower end against an adjustable plug 74. The adjustability of the plug permits adjustment of the compression of the spring 73. The space above the piston 72 is connected by a conduit 75 to a pressure varying device 76 which in this instance has a cylinder 77 with an upper portion 78 reduced in diameter with regard to the lower portion thereof. A pressure varying or device located near the control element, a pressure responsive device located near and connected to the controlled element, each device comprising a cylinder, a piston with a stem movably disposed therein and a biasing spring engaging the piston, the piston and stem of the pressure varying device having equal diameters and forming a passage through which fluid is discharged from the space above said piston, and a valve cooperatively associated with the last mentioned piston and connected to the control element for controlling the flow of fluid through said passage, a conduit for conducting operating fluid under pressure to the space above one of the pistons, a conduit connecting the spaces above the pistons, and a drain conduit connected to the space below the piston of the pressure varying device.

6. A hydraulic remote control mechanism including the combination of a control element, a controlled element, and means for transmitting movement of the control element to the controlled element, comprising a pressure varying device located near the control element, a pressure responsive device located near and connected to the controlled element, each device comprising a cylinder, a piston with a stem movably disposed therein and a biasing spring engaging the piston, the piston and stem of the pressure varying device having equal diameters and forming a passage through which fluid is discharged from the space above said piston, and a valve cooperatively associated with the last mentioned piston and connected to the control element for controlling the flow of fluid through said passage, a conduit for conducting operating fluid under pressure to the space above one of the pistons, a conduit connecting the spaces above the pistons, a drain conduit connected to the space below the piston of the pressure varying device, the two devices being located at different levels, and means for compensating the hydrostatic pressure difference due to said different levels, comprising an adjustable plug engaging one of the springs.

7. A hydraulic remote control mechanism including the combination of a speed governor, a valve for controlling the flow of elastic fluid to an engine, means for transmitting movement of the governor to the valve comprising a first and a second cylinder each having a piston with a stem and a biasing spring for the piston, means connecting the stem of the second cylinder to the valve, conduit means directly connecting the cylinders, means for conducting fluid under pressure to one of the cylinders, means including a bore formed in the piston and the stem of the first cylinder for discharging fluid therefrom, and a valve having a stem connected to the speed governor and located in the bore for controlling the fluid discharge.

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follow-up piston 79 is disposed within the upper portion 78 of the cylinder 77 and connected to a hollow stem 80. The piston 79 is biased upwardly by a compression spring 81 bearing at its upper end against a collar 82 formed on the hollow piston stem 80. Operating fluid is supplied by a conduit 83 including a valve 84 to the upper space in the cylinder 71 whence the fluid flows through the conduit 75 into the cylinder portion 78 to be discharged therefrom through a passage formed by the hollow piston stem 80 and lateral openings 85 in said stem into the lower space of the cylinder 77 which latter is connected to a drain conduit 86. The flow of fluid through the hollow piston stem 80 is controlled by a valve 87 corresponding to the valve 39 in Fig. 1 and connected to a stem 88 which latter is pivoted at its lower end to a fulcrumed lever 89 moved by a speed governor 90 driven from the turbine. In this arrangement, the spaces below the pistons 72 and 79 are no longer connected by a conduit. This is made possible because the diameter D_1 of the pressure varying or follow-up piston 79 is equal to the diameter d_1 of the stem connected thereto. The device 71 is located a distance H above the level of the device 77. In order to compensate the pressure difference in the pressure varying and the pressure responsive devices due to their locations at different levels, an initial or additional compression is imparted to the spring of one of the devices. In the present instance, this may be readily accomplished by properly adjusting the spring plug 74 of the pressure responsive device 71. The ratio of the biasing force of the springs 81 and 73, that is,

$$\frac{P_1}{P_2}$$

is the same as expressed by the above formula if we merely consider P_2 the biasing force of the springs 73 after deduction of an initial force imparted to the spring to compensate for the level difference H.

Having described the method of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof, I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Hydraulic remote control mechanism including the combination of an element responsive to a change in operating condition of a machine to be controlled, a pressure varying device connected to the element and including a cylinder with a follow-up piston having a hollow piston stem and means connected to the element for controlling the flow of operating fluid through the hollow piston stem, a pressure responsive device having a cylinder with a piston having a stem movably disposed therein, a compression spring in each device engaging its piston, means for conducting operating fluid to one of the devices, and conduit means connecting the devices, the dimensions of said devices satisfying the following formula

$$\frac{P_1}{P_2}=\frac{D_1^2(p_2-p_3)+d_1^2p_3}{D_2^2(p_2-p_3)-d_2^2p_3}$$

in which P_1 and P_2 are the biasing forces of the springs, D_1 and D_2 are the inner diameters of the cylinders, d_1 and d_2 are the diameters of the piston stems p_2 and p_3 are the fluid pressures above and below the pistons in said devices.

2. A hydraulic remote control mechanism including the combination of a controlled element, a control element located at a considerable distance from the controlled element, and means for transmitting movement of the control element to the controlled element comprising a pressure responsive device having a cylinder, a piston movably disposed in the cylinder, a stem secured to the piston and connected to the controlled element and a spring engaging the piston, a pressure varying device located near the control element and including a cylinder, a follow-up piston movably disposed therein, a hollow stem with lateral openings secured to the piston, a spring engaging the follow-up piston, and a valve cooperatively associated with the follow-up piston and having a stem connected to the control element, conduit means connecting the spaces formed above and below the pistons of the two devices, a conduit for supplying fluid under pressure to the space above one of the pistons and a conduit for draining fluid from the space below the follow-up piston, the two cylinders and the two piston stems respectively having equal diameters.

3. A hydraulic remote control mechanism including the combination of a control element, a controlled element, means for transmitting movement of the control element to the controlled element comprising a pressure varying device connected to the control element, a pressure responsive device connected to the controlled element, conduit means connecting the two devices and supplying operating fluid under pressure thereto, each device having a cylinder, a piston disposed in the cylinder, a stem connected to the piston and a spring engaging the piston, the pressure varying device in addition including a valve connected to the control element for controlling the flow of operating fluid from the space formed above its piston to the space formed below its piston, the springs of the two devices being dimensioned to satisfy the following formula

$$\frac{P_1}{P_2}=\frac{D_1^2(p_2-p_3)+d_1^2p_3}{D_2^2(p_2-p_3)-d_2^2p_3}$$

in which P_1 and P_2 are the forces exerted by the springs, D_1 and D_2 are the inner diameters of the cylinders, d_1 and d_2 are the diameters of the corresponding piston stems, p_2 are the fluid pressures on one side of the pistons and p_3 are the fluid pressures on the opposite side of the pistons of the two devices.

4. A hydraulic remote control mechanism including the combination of a control element, a controlled element, means for transmitting movement of the control element to the controlled element comprising a pressure varying device mechanically connected to the control element, a pressure responsive device connected to the controlled element, each device having a cylinder, a piston with a stem movably disposed in the cylinder and a biasing spring engaging the piston, a conduit for supplying fluid under pressure to one of the devices, a drain conduit for the pressure varying devices, conduits connecting the spaces above and below the pistons respectively, the diameter of the pistons and their stems as well as the characteristics of the biasing springs being alike.

5. A hydraulic remote control mechanism including the combination of a control element, a controlled element, and means for transmitting movement of the control element to the controlled element, comprising a pressure varying