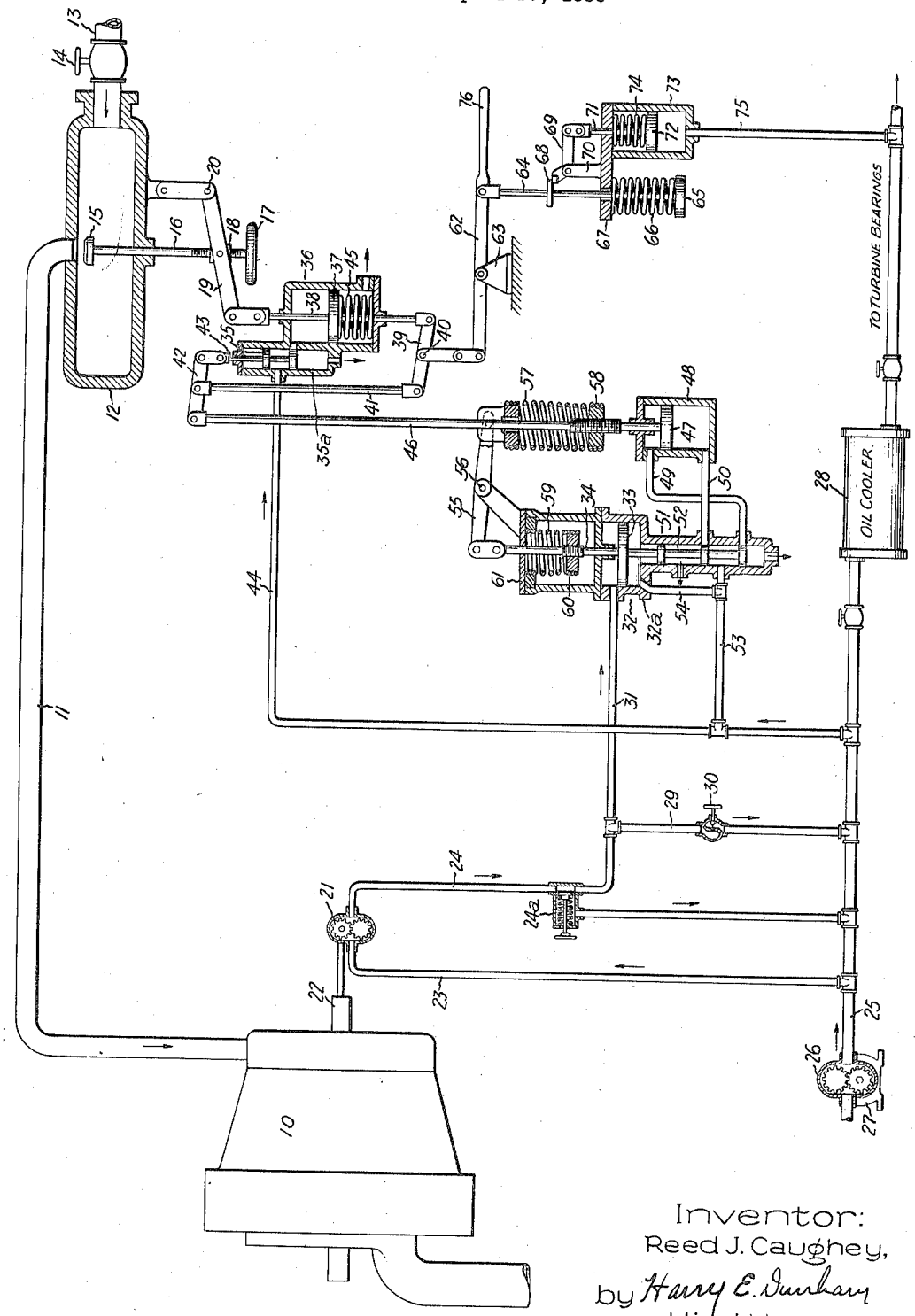
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HYDRAULIC GOVERNING MECHANISM

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HYDRAULIC GOVERNING MECHANISM

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The present invention relates to hydraulic governing mechanisms for prime movers such as are used for controlling the flow of elastic fluid to turbines in response to speed changes. More specifically, the invention relates to the kind of hydraulic governing mechanism in which a speed-responsive device includes a positive displacement pump driven by the prime mover or turbine. In arrangements of this kind, in which the positive displacement pump is connected to a pilot valve and a hydraulic cylinder to cause changes in pressure in an oil supply to the cylinder, a considerable time lag takes place between a change in speed and the response to such change by the hydraulic cylinder or motor for positioning the element to be controlled. This is due to the fact that a considerable change has to be effected in the displacement of oil or like actuating fluid by the positive displacement pump.

One object of my invention is to provide an improved construction and arrangement of hydraulic governing mechanism of the type above specified in which said time lag is considerably reduced. This is accomplished in accordance with my invention by the provision of means connected between the positive displacement pump and the usually provided relay or pilot valve and the hydraulic cylinder or motor whereby a slight change in the amount of oil discharged by the positive displacement pump is sufficient to cause a considerable movement of the hydraulic cylinder and the element to be controlled and connected to said cylinder. In such an arrangement the positive displacement pump which may be a gear pump merely serves to initiate a control movement in response to a speed change, this control movement then being completed by the action of said means connected between the pump and the pilot valve and the hydraulic cylinder.

Another object of my invention is the provision of an improved manual and automatic control mechanism which under certain conditions permits manual control of a controlled element independent of the action of the automatic control mechanism and under other conditions prevents manual control or renders such manual control ineffective.

Still another object of my invention is to provide an improved trip mechanism for effecting closing of a controlled element such as a valve when the bearing pressure of a prime mover or turbine drops to a certain minimum value.

For a better understanding 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 drawing which forms a part of my specification.

The single figure of the drawing illustrates somewhat diagrammatically a hydraulic governing mechanism for a prime mover embodying my invention.

A prime mover, in the present instance an elastic fluid turbine, 10 has an inlet connected by a conduit 11 to a valve chest 12. The latter is connected to a conduit 13 with a valve 14 for conducting elastic fluid to the chest 12. The valve chest includes a valve or valve member 15 for controlling the flow of elastic fluid from the chest to the turbine. The valve member 15 has a stem 16 with a hand wheel 17 secured thereto. A screw-threaded portion of the stem 16 is engaged by a nut 18 which in turn is pivoted to an intermediate point of a lever 19 connected at its right-hand end to a fulcrum 20 and at its left-hand end to an automatic control mechanism as will be described hereinafter.

Let us assume for the moment that the left-hand end of the lever 19 is fixed. Under this condition the valve 15 may be opened and closed manually by the actuation of the hand wheel 17.

Let us now assume the valve 15 closed and the left-hand end of the lever 19 biased in upward direction. Under such condition the valve 15 cannot be opened manually because turning of the hand wheel 17 to cause opening of valve 15 would be compensated by upward movement of the left-hand end of the lever 19. The arrangement, as will be more fully described hereinafter, is such that manual control is rendered ineffective as long as the automatic control mechanism calls for complete closing of the valve.

The automatic control mechanism comprises a positive displacement pump 21. It has an element secured to and driven by a shaft 22 forming a part of the turbine rotor. The pump has a suction conduit 23 and a discharge conduit 24, including a relief valve 24a. In the present instance the suction conduit receives oil from a conduit 25. The conduit 25 receives oil under pressure by the action of another positive displacement pump 26 which may be driven at constant speed by a motor 27. The conduit 25 is connected to the turbine bearings and includes an oil cooler 28 for cooling the oil supplied to the bearings. The flow of oil through the positive displacement pump 21 changes in response and in proportion to speed changes. Hence, this pump constitutes a speed-responsive means. Its discharge conduit 24 is connected by a conduit 29 including a needle valve 30 to the conduit 25 ahead of the oil cooler

28 as regards the direction of flow in the conduit 25. The needle valve 30 serves for speed adjustment of the governing mechanism. The conduit 24 is also connected by a conduit 31 to a pressure-responsive device 32, which latter includes a cylinder 32a and a piston 33 movably disposed in the cylinder and connected to a stem 34.

In the ordinary hydraulic governing mechanism this pressure-responsive device 32 with its stem 34 is either directly connected to the element to be controlled, in the present instance the valve 15, or is connected thereto through the intermediary of a pilot valve and a hydraulic cylinder. A pilot valve 35 having a casing 35a and a hydraulic cylinder 36 are also provided in the present instance. The hydraulic cylinder 36 includes a piston 37 secured to a stem 38 which stem is connected at its upper end to the left-hand end of the lever 19 and at its lower end to the right-hand end of a lever 39 having an intermediate point 40 which for the present we may consider as being fixed, and a left-hand end connected by a rod 41 to a lever 42. The lever has a right-hand end connected to a valve stem 43 of the pilot valve 35. The pilot valve casing 35a is connected by a conduit 44 to the oil supply conduit 25.

During operation, downward movement of the pilot valve stem 43 uncovers a port connecting the pilot valve to the cylinder 36 whereby oil is forced into the cylinder and causes downward movement of the piston 37 against the biasing force of a compression spring 45 disposed in the cylinder. Downward movement of the piston 37 effects opening movement of the valve 15 and it also causes in well known manner through the lever 39 which latter may be termed a "change motion lever" and the rod 41 restoring of the pilot valve to its original position in which the pilot valve stem with its heads covers the port to the hydraulic cylinder.

An increase in speed of the turbine 10 causes an increase in pressure in the conduit 31 and in the upper part of the cylinder 32a resulting in downward movement of the piston 33. Thus, regulation of the turbine valve 15 could be effected by connecting the piston stem 34 to the pilot valve stem 43. In such an arrangement the piston 33 of the pressure-responsive device would have to move a considerable distance, that is, a considerable additional supply of oil into the pressure-responsive device 32 would have to be effected in case of considerable speed changes to cause considerable movement of the pilot valve 35 and the hydraulic motor 36. The resulting time lag of this kind of governing mechanism is considerably reduced in accordance with my invention by the provision of auxiliary means connected between the pilot valve 35 and the pressure-responsive device 32.

The left-hand end of the lever 42 in the embodiment of my invention shown in the drawing is connected to a stem 46 carrying at its lower end a piston 47 movably disposed in an auxiliary hydraulic cylinder or motor 48. The hydraulic cylinder 48 has upper and lower portions connected by conduits 49 and 50 to an auxiliary pilot valve 51. The latter has a casing integrally formed with the cylinder 32a of the pressure-responsive device 32 and a valve stem 52 secured to or forming a continuation of the stem 34. The pilot valve casing is connected by means including a conduit 53 to the oil supply conduit 25. A branch conduit 54 of the conduit 53 serves to supply oil or like actuating fluid to the space formed below the piston 33. The upper end of the stem 34 of the pressure-responsive device 32 is connected to the left-hand end of a lever 55 which has an intermediate point secured to a fulcrum 56 and a right-hand end secured to the upper end of a tension spring 57. The lower end of the tension spring 57 is secured by a nut 58 to the stem 46 of the piston 47. Another tension spring 59 is secured at its lower end by a nut 60 to the piston stem 34 and at its upper end to a fixed support 61. In the present instance the support 61 is securely held on to the upper end of the casing 32a of the pressure-responsive device 32 and forms in turn a support for the fulcrum 56. It is to be noted that both springs 57 and 59 are under tension. The tension of these springs, together with the pressure exerted on the lower surface of the piston 33 constitute a force tending to move the piston 33 upward. This force is normally compensated by the force exerted on the piston in downward direction by the oil pressure from conduit 31 in the upper part of the casing 32a of the pressure-responsive device 32.

The operation of the arrangement is as follows: Let us assume that the various elements are in balanced condition in the position indicated in the drawing. If now the speed of the turbine increases, the flow of oil discharged by the positive displacement pump 21 increases directly with the speed of the turbine. This increase in flow can only be passed through the fixed area of the needle valve 30 by an increase in pressure, which pressure will increase in response to the square of the flow and, therefore, the square of the speed. Hence, an increase in turbine speed causes an increase in pressure on the upper surface of the piston 33 of the pressure-responsive device 32 in proportion to the square of the speed. Due to the fixed loadings of the tension springs 59 and 57, this increase in pressure causes a downward movement of the piston 33 and the pilot valve stem 52 attached thereto. The pilot valve heads secured to the pilot valve stem 52 then uncover their ports and permit the supply of oil through conduit 49 to the upper space in the cylinder 48, and the discharge of oil from the lower space in the cylinder through the conduit 50. This causes downward movement of the piston 47 and its stem 46, which movement causes further tensioning of the spring 57, thus imposing an additional load on the piston 33 of the pressure-responsive device. If the increase in loading of the piston 33, due to the increased tensioning of the spring 57, is sufficient to balance the increased oil pressure on the piston 33, then the piston 33 will stop, leaving the oil supply connected to the top of the piston 47.

If, however, the speed and therefore the oil pressure continues to increase, then further movement of the piston 47 will cause further loading of the piston 33 through increased tensioning of the spring 57 and hold the piston 33 stationary so that a constant opening of the pilot valve 51 is maintained. It is important to note that the piston 47 can make its full stroke while piston 33 is stationary and while the pressure on piston 33 is increasing. If now the speed, and therefore the pressure, stops increasing, a slight additional movement of the piston 47 causes loading of the piston 33 sufficient to move said piston 33 upward to a point where the pilot valve 51 resumes its original position in which the pilot valve heads cover their respective ports. As this takes place, movement of the piston 47 stops.

Downward movement of the piston 47 effects

upward movement of the pilot valve stem 43, permitting the discharge of oil from the hydraulic cylinder 36, resulting in upward movement of the piston 37 and closing movement of the valve 15. Thus, it will be readily understood that with my hydraulic governing mechanism a movement of the piston 47 is obtained which is proportional to the speed of the turbine and which movement is effected by a slight movement of the piston 33. The latter may be termed a governor piston. This slight movement of the piston 33 may be effected by a small quantity of oil from the oil pump. This considerably reduces the time lag of the governing mechanism because it no longer depends on the quantity of oil discharged by the oil pump. The oil pump merely serves to initiate controlling movement by effecting a slight movement of the piston 33, which movement in turn controls the position of the pilot valve 52 and effects, through movement of the piston 47, increased or decreased loading of the piston 33, depending upon whether an increase or a decrease respectively of the turbine speed takes place. The device 32 is not a pressure-responsive device in the ordinary sense. It is pressure-responsive in so far as movement of the piston 33 takes place in response to a change in pressure in the line 31. A further increase in pressure or, from another viewpoint, a continued increase in pressure, however, does not cause an additional or further movement of the piston 33 but causes, through the pilot, valve 51 and the auxiliary cylinder 48 with its piston 47, tensioning of the spring 57, that is, further loading of the piston 33. Looking at the device from another viewpoint, in an ordinary pressure-responsive device, continued increase in pressure causes continued movement of such pressure-responsive device. In this particular device 32 the initial pressure change only causes movement of the pressure-responsive device, whereas the continued or further pressure change causes tensioning or loosening of the spring or springs, that is, loading or unloading of the device. The device depends only on increments of pressure changes due to changes in speed of the pump 21 and does not depend on changes in oil pressure due to speed changes of the other pump 26 because the lower side of the piston 33 is subject to the pressure in the conduit 25. Hence, pressure changes in this conduit will equally affect both the upper and the lower side of the piston 33.

As stated above, under certain conditions the valve 15 may be operated manually by the wheel 17. This operation is possible only as long as there is sufficient oil pressure in the cylinder 36 to resist movement of the piston 37 by the action of the compression spring 45. The valve 15 connot be opened when it is completely closed by the action of the piston 37, because in this case no oil pressure is exerted on the upper face of the upper side of the piston 37 and manual opening of the valve 15 is compensated due to upward movement of the piston 37 by the action of the spring 45.

Means are provided in accordance with my invention for tripping or closing the valve 15 when the pressure in the conduit 25 drops to a certain minimum value. The conduit 25, as stated above, serves to conduct oil under pressure to the bearings. In order to keep the bearings properly lubricated and safeguard them it is desirable to supply oil or like lubricant under a certain pressure and to stop operation of the turbine in case this pressure drops to a certain minimum value. This means, which may be termed a low oil pressure trip mechanism, comprises a lever 62 which has an intermediate point supported on a fulcrum 63 and is connected at its left-hand end to the intermediate point 40 of the lever 39 and at its right-hand portion to a steam 64 which latter is secured to a washer 65. The washer 65 is loaded by a compression spring 66 intermediate the washer and a fixed support 67. A latching collar 68 secured to the stem 64 is engaged by a lever 69 which latter has an intermediate point connected to a fulcrum 70 and a right-hand end pivoted to a stem 71. The lower end of the stem 71 is fastened to a piston 72 slidably arranged in a cylinder 73 and biased downward by a compression spring 74. The biasing force of the compression spring is normally compensated by oil pressure in the lower space of the cylinder 73, which space communicates through a pipe 75 with the conduit 25. When the bearing oil pressure drops to a certain minimum value, the piston 72 is forced downward by the action of the spring 74. This causes unlatching of the collar 68, whereby the stem 64 with the piston 65 are moved downward by the action of the compression spring 66. This in turn causes clockwise turning movement of the fulcrum lever 62, resulting in upward movement of the pilot valve stem 43 and consequently upward movement of the piston 37 in the hydraulic cylinder 36, thereby effecting closing of the valve 15. Return of the bearing oil pressure will restore the piston 72 to its upper position but will not effect opening of the valve 15 until the latch collar 68 is raised by the operator. To this end, the lever 62, which may be termed a resetting lever, has a right-hand extension or handle 76.

As stated above, the speed of the turbine may be adjusted by adjustment of the needle valve 30. In case the governing mechanism is to be used as an over-speed device, the speed-adjusting needle valve 30 is placed in wide open or high speed position.

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. A prime mover including the combination of a control element for controlling the supply of fluid to the prime mover, and a governing mechanism for positioning the control element in response to speed changes of the prime mover, said governing mechanism including a cylinder having a first piston with a stem therein, a positive displacement pump driven by the prime mover and connected to one side of said piston, an auxiliary cylinder with a second piston, means including a stem for connecting the second piston to the control element, means including another pump independent from the positive displacement pump and a pilot valve connected to the first piston for conducting actuating fluid to the auxiliary cylinder, and other means for loading the first piston to counteract further pressure changes after an initial movement of the first piston in response to movement of the second piston comprising a fulcrumed lever having one end connected to the stem of said first named piston and a tensioned spring connected between the other end of the lever and the stem of the auxiliary piston to reduce the time lag between a speed

change and the response thereto by the auxiliary piston.

2. A governing mechanism including the combination of a pressure-responsive device having a movable member, a positive displacement pump for forcing fluid at variable pressure into said device, a motor, means including a source of fluid under pressure independent from the pump for actuating the motor in response to movement of the movable member, and means for reducing movement of the movable member during pressure changes in response to movement of both the pressure-responsive device and the motor, said pump having an inlet connected to said source.

3. A governing mechanism including the combination of a positive displacement pump, a pressure-responsive device having a movable element and being connected to the pump to effect movement of the element in response to speed changes of the pump, a motor, means including a source of fluid under pressure independent from the pump for actuating the motor in response to movement of said element, means for reducing movement of said element during pressure changes in response to movement of the motor, said pump having an inlet connected to said source, and a by-pass with an adjustable valve for the pump.

4. A governing mechanism including the combination of a positive displacement pump subject to varying speed, a pressure-responsive device having a movable element and being connected to the pump, a hydraulic motor having a piston, a source of fluid under pressure independent from the pump, a pilot valve moved by the pressure-responsive device for controlling the flow of actuating fluid from the source to the hydraulic motor, and means for reducing the amount of fluid to be forced into the pressure-responsive device during sudden considerable load changes comprising a lever, a fulcrum supporting a central portion of the lever, means connecting one end of the lever to the movable element and a spring connecting the other end of the lever to the piston to reduce the time lag between the pump and the motor.

5. A governing mechanism including the combination of a pressure-responsive device having a movable element, pumping means responsive to speed changes of an engine to be controlled for forcing fluid into the pressure-responsive device, a motor, a source of fluid under pressure independent from the device and connected to the motor, means for controlling the flow of fluid from the source to the motor in response to movement of said element, biasing means normally holding said element in a fixed position against the force exerted thereon by the fluid-pressure of the pumping means, and means increasing the biasing force on said element in response to movement of the motor to reduce the time lag between the device and the motor.

REED J. CAUGHEY.