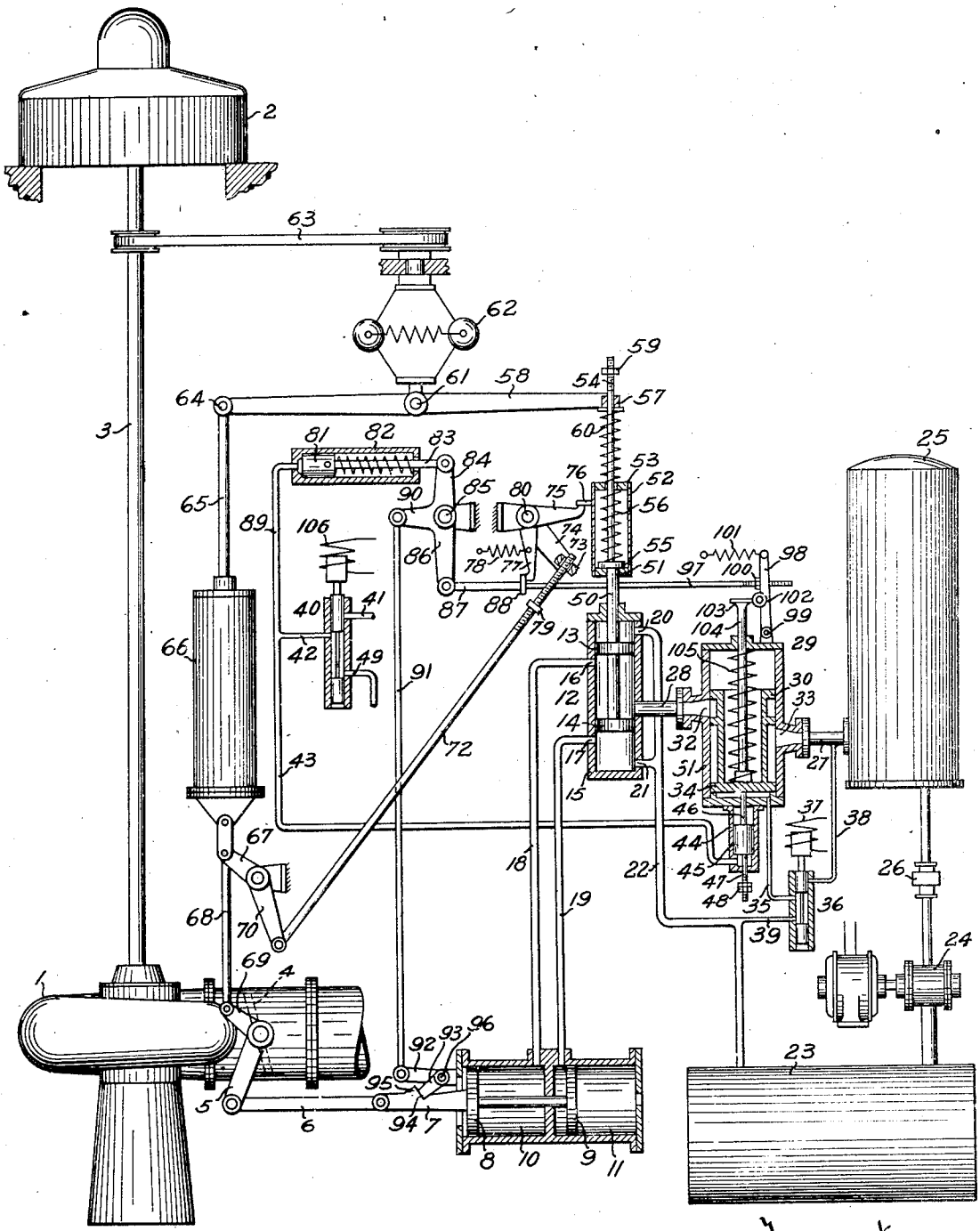
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R. H. EARLE

PRIME MOVER CONTROL SYSTEM

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PRIME-MOVER CONTROL SYSTEM.

Application filed July 31, 1924. Serial No. 729,223.

To all whom it may concern:

Be it known that RALPH H. EARLE, a citizen of the United States, residing at Wauwatosa, in the county of Milwaukee and State of Wisconsin, has invented a certain new and useful Prime-Mover Control System, of which the following is a specification.

This invention relates to prime mover control systems.

One of the objects of the invention is to provide a control system for a prime mover whereby the prime mover may be automatically started and stopped. Another object is to bring the prime mover to the normal running condition under speed control. A more specific object is the provision of a system whereby the prime mover may be slowly started and stopped.

Another object of the invention is the provision of a control system for a prime mover in which a single control element serves to restrict the application of power to a means for controlling the admission of operating fluid to the prime mover either during the starting or stopping period and which element also serves to permit the application of a full amount of power to said admission controlling means while the prime mover is in its normal running condition so that better regulation of the prime mover may be effected.

In combination with certain aspects of the invention it is also an object to provide means for cushioning the closing movement of the means for admitting operating fluid to the prime mover.

A further object is to provide a system accomplishing one or more of the stated and other objects which is particularly applicable to prime movers in which the means for controlling the admission of operating fluid thereto tends to stand open under the influence of the operating fluid. Other objects will appear hereinafter as the description of the invention proceeds.

The novel features of the invention will appear from this specification and the accompanying drawing forming a part thereof and disclosing one embodiment of said invention and all these novel features are intended to be pointed out in the claims.

The single figure of the drawing is a diagrammatic view showing the invention as it may be applied to a hydraulic turbine.

Referring to the drawing, the prime mover here shown is a hydraulic turbine 1 adapted to drive a generator 2 or other translating device through a shaft 3. Admission of water to the turbine may be controlled by means of a gate 4 in the water supply conduit. The gate 4 is here shown as pivoted below the center of the gate so that there is a tendency for the water, when the gate 4 is closed to open said gate. It is to be understood that the turbine may be controlled by any other suitable means such as the usual guide vanes which also, in certain instances, are so pivoted that the water tends to open them. Inasmuch as these guide vanes serve the same purpose as the gate 4, the term "gate" will therefore be used hereinafter as connoting any means for admitting operating fluid to a prime mover. The gate 4 is operable by means of a crank 5 connected by a rod 6 to a piston rod 7. The piston rod 7 is here shown as operable by two pistons 8, 9, forming part of a servomotor, working in two separate cylinders 10, 11. The admission of fluid under pressure to cylinders 10, 11 is controlled by means of a regulating valve 12 provided with two spaced piston valves 13, 14 operating in a cylinder 15. When the regulating valve is in its neutral position the piston valves 13, 14 are adapted to close ports 16, 17 respectively in cylinder 15. Ports 16, 17 are here shown as connected by means of pipes 18, 19 with cylinders 10, 11 respectively. As viewed in the drawing, the cylinder 15 is also provided with drain ports 20, 21 respectively above and below piston valves 13, 14. These drain ports may be connected by means of a pipe 22 with a receiving tank 23. Fluid may be drawn from the receiving tank 23 by means of a motor-driven pump 24 which delivers the fluid to a pressure tank 25. A check valve 26 may be introduced between the pump 24 and tank 25 so that when the pump is not in operation there will be no loss of fluid from the tank.

The tank 25 may be connected by means of pipes 27, 28 to a port in cylinder 15 preferably located between the piston valves 13, 14. Interposed between pipes 27, 28 is a shut-off or control valve 29, having ports 32, 33. This valve includes a piston valve 30, operating in a cylinder 31, adapted in the position of the parts shown to close the port 32 com-

municating with pipe 28 thereby interrupting communication between pipes 27, 28. The piston valve 30 is biased to the position shown in the drawing by means such as a spring 105. The lower end of the piston valve 30 is here shown as formed to constitute an operating piston 34 working in cylinder 31. In order to supply fluid under pressure for raising piston 34 a pipe 35 is provided communicating with the space below piston 34. The admission of fluid under pressure to pipe 35 may be controlled by means of an electromagnetically operated valve 36 provided with an operating coil 37. The coil 37 may be supplied with current from any suitable source (not shown) which current may of course be controlled by means of a switch or relay under predetermined conditions. The electromagnetic valve 36 normally closes communication, when coil 37 is deenergized, between pipe 35 and a pipe 38 communicating with the pressure tank 25. The valve 36 may be provided with a drain port communicating with a pipe 39 leading to the receiving tank 23.

Another electromagnetically operated valve 40, having an operating coil 106, is provided for a purpose to be hereinafter set forth. This valve may be supplied by fluid under pressure from tank 25 by means of a pipe 41, the valve normally closing communication when its operating coil is deenergized, between pipe 41 and a pipe 42. Here shown as connected with pipe 42 is a pipe 43 leading to a cylinder 44 in which a piston 45 is adapted to operate. The piston 45 is provided with a rod 46 passing through the lower end of cylinder 31 and adapted to raise piston 34. The upward motion of piston 45 may be limited by means of a rod 47 provided with adjustable nuts 48 adapted to abut against the lower end of cylinder 45 when piston 45 is lifted a predetermined amount.

The regulating valve 12 may be controlled by means of fly balls 62 and to this end a rod 50 by which the piston valves 13, 14 are carried is here shown as provided with a collar 51 forming the lower end of a tube 52. The other end 53 of the tube is provided with a hole through which a rod 54 is adapted to freely pass. The rod 54 is provided at its lower end within tube 52 with a stop collar 55 between which and the tube-end 53 is disposed a spring 56. The upper end of rod 54 passes freely through a swivel nut 57 mounted on a floating lever 58. The upper end of rod 54 is threaded and provided with adjustable nuts 59 against which the swivel nut 57 is adapted to abut in order that the floating lever 58 may raise the rod 50 of the regulating valve. A spring 60 is disposed about the rod 54 between the tube-end 53 and the swivel nut.

The floating lever 58 is adapted to swing about and be raised and lowered by means of a floating pivot 61 controlled by means of the fly balls 62 which are driven by any suitable means so as to be responsive to the speed of the prime mover, as by means of a belt 63. The other end of the floating lever is provided with a pivot 64 which is connected by means of a piston rod to the piston of a dash pot or compensating device 66 which may be of usual or desired form. The compensating device 66 may be raised and lowered by means of a crank 67 connected by means of rod 68 to a crank 69 operating in unison and positioned in accordance with the gate 4. Also positioned in accordance with gate 4 is a load limiting device which includes a crank 70 operating in unison with crank 67, connected by means of a rod 72 to a control finger 75, swingable about a stationary pivot 80. To this end the rod 72 is adapted to pass freely through a swivel nut 73 mounted on a crank 74 operating in unison with control finger 75. The rod 72 is provided with an adjustable nut 79 which is adapted, when gate 4 is opened a predetermined amount, to abut against swivel nut 73 thereby swinging control finger 75 in a counter-clockwise direction. This motion will cause control finger 75 to engage a projection 76 here shown as associated with the tube 52. The counter-clockwise motion of control finger 75 is therefore adapted to move the regulating valve toward the gate-closed position, thereby compressing spring 60 more or less depending upon the position of the floating lever 58.

The control finger 75 is also controllable by means of a piston 81 operating in a cylinder 82 and biased, as by a spring, to the position shown in the drawing. Piston 81 is provided with a rod 83 pivoted to one end 84 of a lever swingable about a stationary pivot 85. The oppositely extending end 86 of the lever is pivotally connected to a rod 87 provided with a collar 88 adapted to engage a crank 77 operating in unison with control finger 75. The crank 77 is here shown as biased in a clockwise direction by means of a spring 78. This will of course also bias control finger 75 and the crank 74 in the same direction. Fluid under pressure may be admitted to cylinder 82 to force piston 81 against the bias of its spring by means of a pipe 89 here shown as connected to pipe 42 and therefore also controlled by valve 40.

The motion of lever 86 is also adapted to be controlled by and to control a rod 91 pivotally connected to an extension 90 operating in unison with lever 84—86. The lower end of rod 91 is pivotally connected to a crank 92 swingable about a stationary pivot 96. Crank 92 is adapted to operate in unison with a latch 93 also swingable about pivot 96. Latch 93 is adapted to engage a notch or detent 94 provided in piston

rod 87 or formed by a hump 95 on said rod.

The rod 87 is also adapted to control certain of the motions of valve 29 and to this end said rod is provided with an extension 97 here shown as passing freely through a latch 98 swingable about a stationary pivot 99. In order that motion of rod 97 to the right, as viewed in the drawing, may swing latch 98 in a clockwise direction said rod is provided with a collar 100 adapted to abut against latch 98. Latch 98 is biased in a counter-clockwise direction by means of a spring 101. The latch 98 is provided with a roller 102 adapted, when the latch is permitted to swing in a counter-clockwise direction, to go beneath a detent 103 on a rod 104 connected with piston valve 30. The detent 103 and latch 102 are relatively so positioned or adjusted that when piston valve 30 is opened slightly to a predetermined extent roller 102 will be in a position, when released by collar 100, to go beneath detent 103, thus preventing downward movement of valve 30 until latch 98 is released.

The operation of the system is as follows. In order to start the turbine from rest the operating coil 106 of the valve 40 is energized thereby admitting fluid under pressure to cylinders 82 and 44. The piston 45 raises piston valve 30 sufficiently to admit a small amount of pressure to regulating valve 12 and therefore through port 16 and pipe 18 to cylinder 10 thereby forcing piston 8 to thoroughly seat the gate 4 against the pressure of the water tending to open it. This releases the back pressure on latch 93 and piston 81 is therefore enabled to withdraw said latch freely. The movement of piston 81, transmitted through rod 87, lever 77 and control finger 75, permitting the latter to swing in a clockwise direction, also permits the piston rod 50 of the regulating valve to move downwardly under the influence of spring 60. When the regulating valve has reached neutral position latch 93 will have been withdrawn fully from its detent. Further movement of piston 81 permits the regulating valve to move toward the gate-open position thereby admitting fluid under pressure of a predetermined small amount, as controlled by the amount that piston 45 has opened the control valve 29, to cylinder 11, thereby moving piston 9 slowly toward gate-open position. The turbine will start to rotate when the gate-opening is sufficient to cause the water to overcome the starting resistance of the turbine and whatever translating device may be connected thereto. As the turbine rises in speed the fly balls 62, depending upon their adjustment, will at a predetermined speed affect the position of the regulating valve 12 through the floating lever 58 as is clear. The compensating dash pot mechanism 66 operates in the well known manner. When the turbine has reached the desired predetermined speed, (or in response to any predetermined condition) the operating coil 37 of the valve 36 may be energized thereby admitting fluid under pressure beneath piston 34. This results in the complete opening of the control valve 29 so that the amount of fluid pressure available for the operation of the servo-motor is no longer restricted. The servo-motor will therefore respond more quickly to the controlling action of the regulating valve 12 so that the fly balls will tend to operate to maintain the speed of the turbine substantially constant under predetermined load conditions. The load limiting device, if provided, will act to prevent the turbine from assuming more than a predetermined load by reason of the fact that when the gate 4 opens a predetermined amount, as determined by the adjustment of nut 79, the rod 72, having been moved in a generally upward direction, causes nut 79 to engage swivel nut 73 to thereby swing the control finger 75 in a counter-clockwise direction resulting in movement of the regulating valve 12 toward the gate-closed position. This therefore checks any further gate opening movement.

When it is desired to stop the turbine, both coils 37 and 106 are deenergized thereby cutting off fluid pressure from below piston 34 and from piston 81. Both of these pistons therefore will be urged to the position shown in the drawing under the influence of the respective springs acting thereagainst. Piston 34, however, will not descend any further than will be permitted by latch 98 which latter is in a position so that the roller 102 will be engaged by the detent 103. This insures, as will appear, that a small amount of fluid pressure will be maintained on the servo-motor under predetermined conditions. As the piston 81 moves to the left under the influence of its spring it swings control finger 75 toward the gate-closed position thereby admitting fluid under pressure to cylinder 10. As piston 8 moves toward the gate-closed position latch 93 will ride on top of the left hand end of piston rod 7. The counter-clockwise motion of latch 93 is thus limited to an extent sufficient so that the spring tending to urge piston 81 toward the left cannot act to move the rod 97 toward the right to release latch 98. The valve 29 is therefore maintained in its partially open position. Further movement of piston rod 7 to the left causes the hump 95 to lift latch 93 thereby permitting the regulating valve 12 to be moved by spring 60 from its gate-closed position to almost the neutral position thereby reducing the fluid pressure in cylinder 10. This reduces the closing speed of gate 4 and cush-

ions the closing thereof. Further movement of piston 8 toward gate closed position permits latch 93 to drop into the notch 94 and also permits the spring urging piston 81 toward the left to move rod 97 to the right to release latch 98. Control valve 29 closes completely and fluid pressure is cut off from the regulating valve and servo-motor. Inasmuch however as the gate 4 is now latch closed it cannot be opened by the water pressure even though there is no pressure in cylinder 10. In case there should be a stick or other obstruction preventing complete closure of gate 4, latch 93 would not fall into notch 94 and therefore latch 98 would not be released. Fluid pressure will therefore be maintained on the regulating valve 12 and the servo-motor to keep gate 4 closed as much as the obstruction preventing its complete closure will permit.

It should be understood that it is not desired to limit the invention to the exact details of construction shown and described, for obvious modifications may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:-

1. In a system for starting a prime mover, a gate for admitting operating fluid to said prime mover, means for operating said gate at a normal rate and at a slower rate, means for holding said gate in closed position, means for causing said operating means to apply force to said gate toward gate-closed position when said gate is in closed position, means for releasing said holding means, and means for then causing said operating means to operate said gate at said slower rate.

2. In a system for starting a prime mover, a gate for admitting operating fluid to said prime mover, means for operating said gate at a normal rate and at a slower rate, means for holding said gate in closed position, means for causing said operating means to apply force to said gate toward gate-closed position when said gate is in closed position, means for releasing said holding means, means for then causing said operating means to operate said gate at said slower rate, and means for permitting said operating means to operate said gate at said normal rate upon the occurrence of predetermined conditions.

3. In a system for starting a prime mover, a gate for admitting operating fluid to said prime mover, means for operating said gate at a normal rate and at a slower rate, means for holding said gate in closed position, means for causing said operating means to apply force to said gate toward gate-closed position when said gate is in closed position, means for releasing said holding means, means for then causing said operating means to operate said gate at said slower rate, means responsive to the speed of said prime mover for controlling said operating means, and means for permitting said operating means to operate said gate at said normal rate in response to the control of said speed responsive means.

4. In a control system for stopping a prime mover, a gate for admitting operating fluid to said prime mover, means for operating said gate at a normal rate and at a slower rate, a single control element for controlling the supply of power to said operating means, and means for causing said control element to reduce the supply of power to an amount sufficient to operate said gate at said slower rate and maintain said supply at said amount until said gate is substantially closed.

5. In a control system for stopping a prime mover, a gate for admitting operating fluid to said prime mover, means for operating said gate, a single control element for controlling the supply of power to said operating means, and means for preventing said control element from entirely cutting off the supply of power until said gate is closed.

6. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, a control valve for admitting fluid under pressure to said regulating valve, and means for opening said control valve partially a predetermined amount to slowly open said gate.

7. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, a control valve for admitting fluid under pressure to said regulating valve, means for opening said control valve partially a predetermined amount to slowly open said gate, and means responsive to predetermined conditions for fully opening said control valve.

8. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means responsive to the speed of said prime mover for controlling said regulating valve, a control valve for admitting fluid under pressure to said regulating valve, and means for opening said control valve partially a predetermined amount to slowly open said gate.

9. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means responsive to the speed of said prime mover for controlling said regulating valve, a control valve for admitting fluid under pressure to said regulating valve, means for opening said control valve par-

tially a predetermined amount to slowly open said gate, and means responsive to predetermined conditions for fully opening said control valve.

10. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means for controlling the position of said regulating valve to start and stop said prime mover, a control valve for admitting fluid under pressure to said regulating valve, and means for opening said control valve partially a predetermined amount to slowly open said gate.

11. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means for controlling the position of said regulating valve to start and stop said prime mover, a control valve for admitting fluid under pressure to said regulating valve, means for opening said control valve partially a predetermined amount to slowly open said gate, and common means for controlling said means for controlling the position of said regulating valve and said means for opening said control valve a predetermined amount.

12. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means for controlling the position of said regulating valve to start and stop said prime mover, a control valve for admitting fluid under pressure to said regulating valve, means for opening said control valve partially a predetermined amount to slowly open said gate, common means for controlling said means for controlling the position of said regulating valve and said means for opening said control valve a predetermined amount, and means responsive to predetermined conditions for fully opening said control valve.

13. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, a control valve for controlling a supply of fluid under pressure to said regulating valve, means for moving said regulating valve to gate-closed position to cause said gates to move toward closed position, means for preventing complete closure of said control valve during the gate closing movement, and means for permitting complete closure of said control valve when said gate is in closed position.

14. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, a control valve for controlling a supply of fluid under pressure to said regulating valve, means for moving said regulating valve to gate-closed position to cause said gates to move toward closed position, means for preventing complete closure of said control valve during the gate closing movement, means effective when said gate is almost closed to return said regulating valve toward neutral position a predetermined amount, and means for permitting complete closure of said control valve when said gate is in closed position.

15. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, a control valve for controlling a supply of fluid under pressure to said regulating valve, means for moving said regulating valve to gate-closed position to cause said gates to move toward closed position, means for preventing complete closure of said control valve during the gate closing movement, means effective when said gate is almost closed to return said regulating valve toward neutral position a predetermined amount, means for permitting complete closure of said control valve when said gate is in closed position, and means for causing said regulating valve to again move to gate-closed position when said gate is completely closed.

16. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means responsive to the speed of said prime mover for controlling said regulating valve, a control valve for admitting fluid under pressure to said regulating valve, a fluid pressure operated piston for partially opening said control valve, and a second fluid pressure operated piston for completely opening said control valve.

17. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means responsive to the speed of said prime mover for controlling said regulating valve, a control valve for admitting fluid under pressure to said regulating valve, a fluid pressure operated piston for partially opening said control valve, a second fluid pressure operated piston for completely opening said control valve, a third fluid pressure operated piston, and a control member operable by said third piston operatively related to said regulating valve.

18. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means responsive to the speed of said

prime mover for controlling said regulating valve, a control valve for admitting fluid under pressure to said regulating valve, a fluid pressure operated piston for partially opening said control valve, a second fluid pressure operated piston for completely opening said control valve, a third fluid pressure operated piston, a control member operable by said third piston operatively related to said regulating valve, and a latch controlled by said third piston for holding said control valve in partially open position.

19. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means responsive to the speed of said prime mover for controlling said regulating valve, a control valve for admitting fluid under pressure to said regulating valve, a fluid pressure operated piston for partially opening said control valve, a second fluid pressure operated piston for completely opening said control valve, a third fluid pressure operated piston, a control member operable by said third piston operatively related to said regulating valve, a latch controlled by said third piston for holding said control valve in partially open position, and a latch controlled by said third piston for holding said gate in closed position.

20. In a control system for a prime mover, a gate for admitting operating fluid to said prime mover, a servo-motor for operating said gate, a regulating valve for said servo-motor, means responsive to the speed of said prime mover for controlling said regulating valve, a control valve for admitting fluid under pressure to said regulating valve, a fluid pressure operated piston for partially opening said control valve, a second fluid pressure operated piston for completely opening said control valve, a third fluid pressure operated piston, a control member operable by said third piston operatively related to said regulating valve, a latch controlled by said third piston for holding said control valve in partially open position, a latch controlled by said third piston for holding said gate in closed position, and means positioned in accordance with said gate for controlling said control member.

In testimony whereof, the signature of the inventor is affixed hereto.

RALPH H. EARLE.