

April 5, 1960

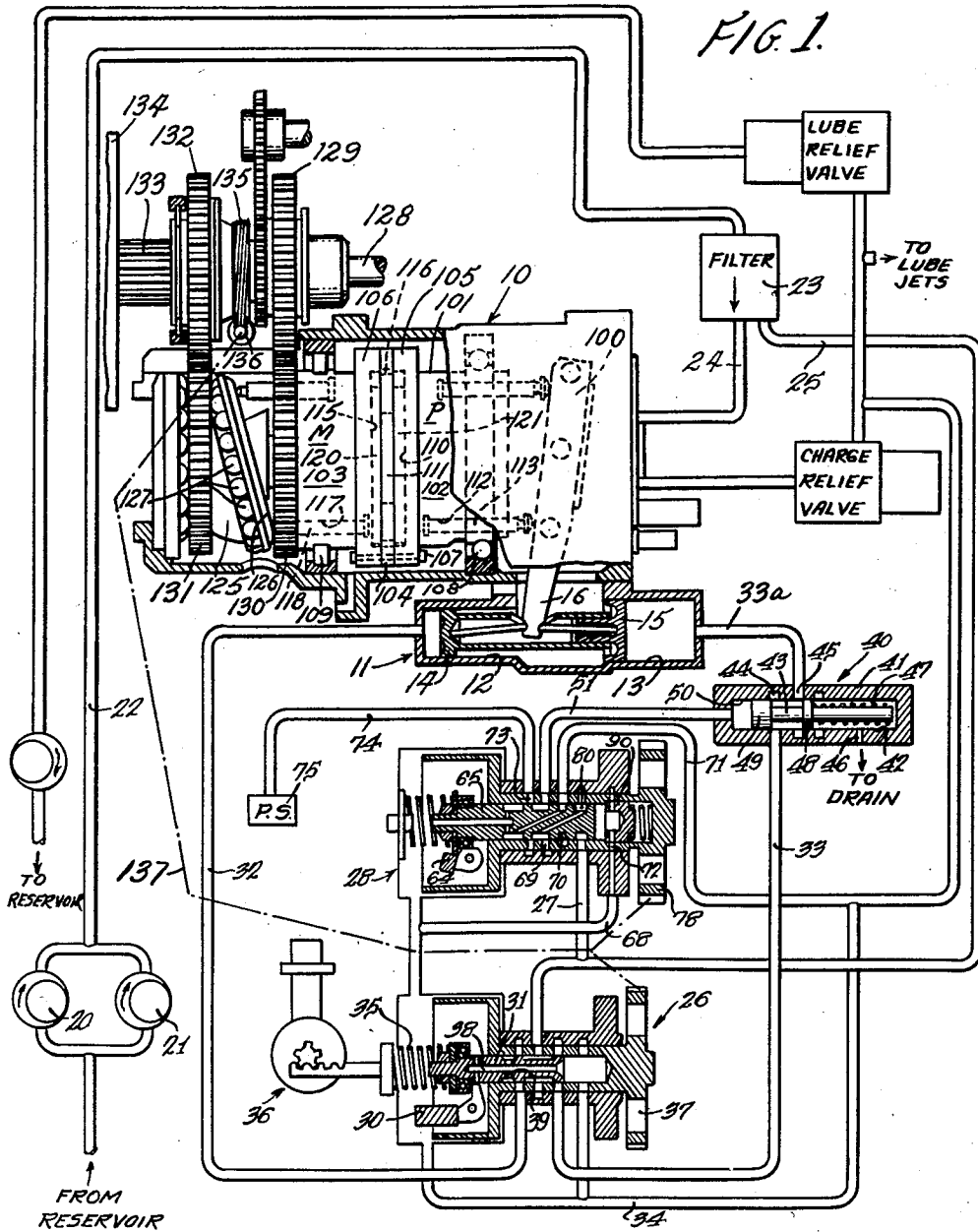
K. A. TEUMER

2,931,177

CONTROL SYSTEM

Filed June 26, 1957

2 Sheets-Sheet 1



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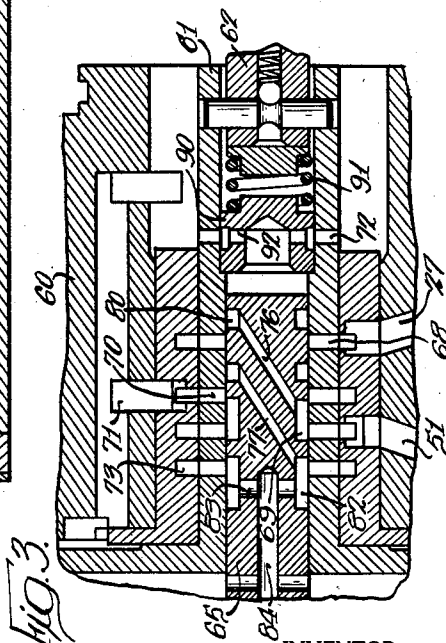
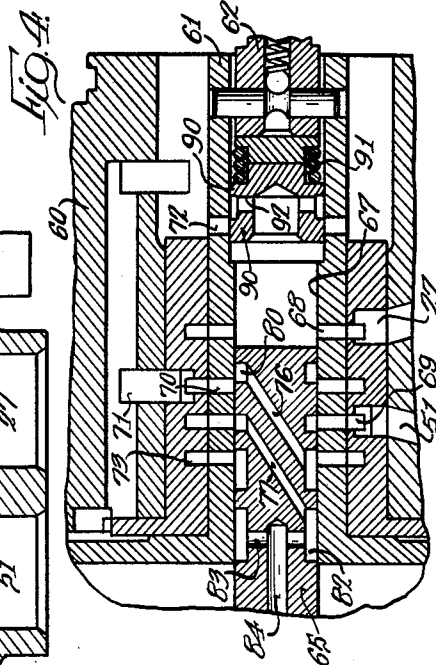
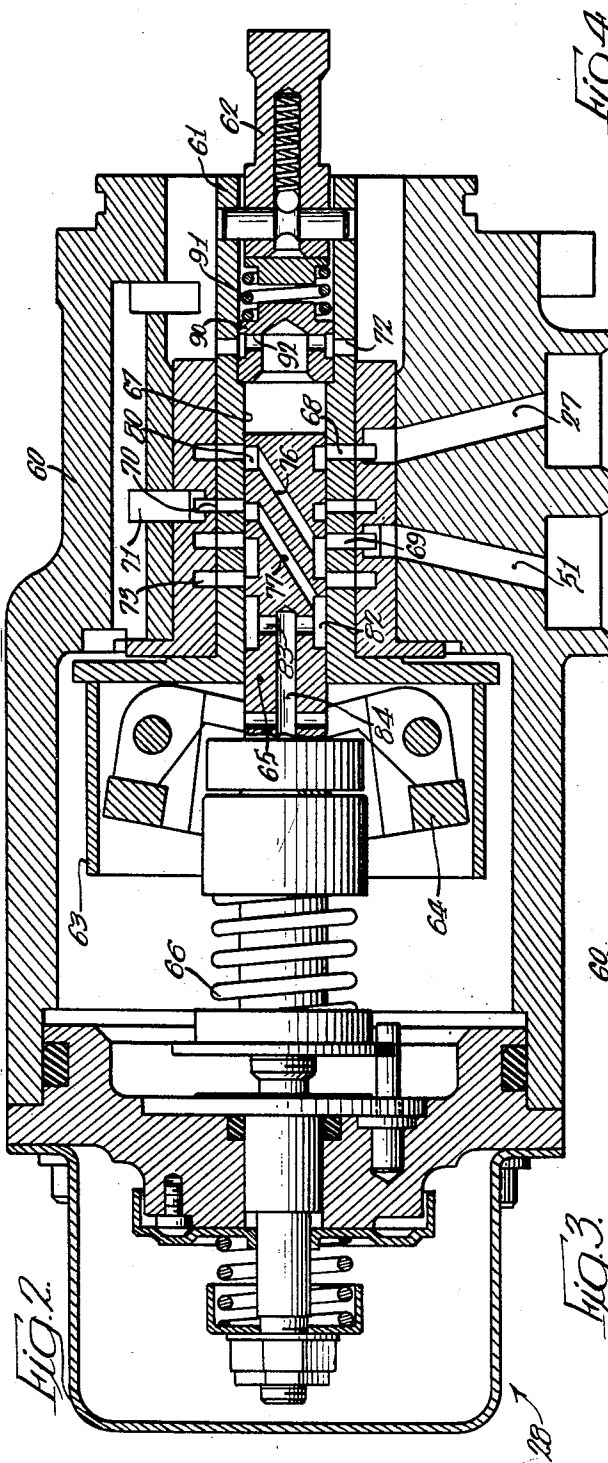
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2 Sheets-Sheet 2



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2,931,177

CONTROL SYSTEM

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6 Claims. (Cl. 60—53)

This invention relates to a control system and more particularly to a hydraulic control system for controlling the speed of a driven apparatus.

It is the general object of the present invention to produce a new and improved hydraulic control system.

It is a more specific object of the present invention to produce a new speed control system wherein two speed sensing devices are utilized, one to control the speed of the apparatus over a normal operating range and the other to take over control when the speed varies substantially above or below a normal operating range.

Still another object of the present invention is to produce a speed control system wherein a first fly ball governor is utilized to control the speed of an apparatus over a normal range and a second fly ball governor is provided for the purpose of controlling the speed of the apparatus independently of the first governor should the speed of the apparatus vary materially from a normal operating speed.

A further object of the invention is to produce a valve particularly adapted for operation by a governor wherein an orifice-forming member is provided for reducing the size of a drain opening in the bore of the valve under certain operating conditions.

Other and further objects and advantages of the invention will be readily apparent from the following description and drawings in which—

Fig. 1 is a schematic circuit diagram illustrating an embodiment of the invention;

Fig. 2 is an enlarged longitudinal sectional view of a fly ball governor and valve construction of the invention;

Fig. 3 is a view of the valve portion of Fig. 2 but showing the valve in a second position, and

Fig. 4 is a view like Fig. 3 showing the valve in a third position.

While the invention herein disclosed is shown in its preferred embodiment it is not intended to limit the invention to the specific form and arrangement shown, it being contemplated that various changes may be made by those skilled in the art without departing from the spirit and scope of the invention as pointed out in the appended claims.

Referring now to Fig. 1 of the drawings, the invention is shown as utilized in a system to control the output of a hydraulic transmission 10, which transmission may be of the type illustrated in the copending application of Carl L. Sadler et al., filed December 4, 1951, as Serial Number 259,872, now Patent No. 2,803,112 issued August 20, 1957.

As illustrated in the foregoing patent and as best seen in Fig. 1, the transmission 10 includes a hydraulic power and speed conversion unit, which unit in turn is comprised of a pump P and a motor M, each of the reciprocating piston type, with the pump having the wobbler 100 adjustable in varying amounts to either side of neutral position to vary the direction as well as the quantity

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of fluid discharged from the pump to the motor. The hydraulic transmission 10 as here shown is of the rotatable barrel or cylinder block type, and has the pump as well as the motor cylinders formed in the same rotatable cylinder block 101. Such a construction permits of readily obtaining rotation of the motor shaft at a speed above or below that of the cylinder block, and hence of obtaining the constant speed of the motor shaft regardless of the rate of rotation of the cylinder block by adjustment of the wobbler 100. Adjustment of the wobbler 100 with respect to neutral determines whether the motor shaft is driven faster or slower than the cylinder block 101 and the extent that the wobbler 100 is swung from its neutral position determines the differential between the speeds of the cylinder block and the motor shaft, the pump and motor parts being locked and the cylinder block and the motor shaft rotating at the same speed when the wobbler is in neutral position.

The rotatable cylinder block 101 comprises a pump block 102, a motor block 103 and an annular spacer plate 104. The pump and motor blocks are assembled in line so as to maintain the outside diameter of the cylinder block 101 to a minimum, adapting the unit for high speed operation in which centrifugal forces are kept at a minimum. The pump and motor blocks are secured in end to end relationship, being spaced only by the plate 104. To that end, the blocks 102 and 103 are formed, respectively, with radially outwardly extending flanges 105 and 106 and passing through these flanges and through the plate 104 are a plurality of bolts 107 by means of which the parts are secured together in fluid-tight relationship.

The cylinder block 101 is rotatably supported in two sets of bearings 108 and 109.

The face of the pump block 102 adjacent the plate 104 is formed with a shallow circular recess 110 which with the plate 104 forms a valve chamber at all times in free communication with a chamber 111 formed by the center of the annular plate 104. Also formed in the block 102 is a plurality of annularly arranged cylinders 112 disposed in parallel relationship with the axis of the unit and opening at the right-hand end as seen in Fig. 1 through the end of the block 102 and opening at the left-hand end to the valve chamber 110. The number of cylinders 112 is large, being in the order of eighteen. Reciprocable in each cylinder 112 is a piston 113 and operable to project in all positions from the right-hand end of the cylinder and in contact with the face of the wobbler 100.

Formed in the corresponding face of the motor block 103 is a shallow, circular recess 115 similar to the recess 110 and likewise forming with the plate 104 a valve chamber in constant communication with the chamber 111. The valve chambers 110 and 115 in addition to being in communication through the chamber 111 are in communication at their peripheries through a plurality of longitudinal passages 116 formed in the plate 104. Also formed in the motor block 103 is a plurality of annularly arranged cylinders 117 disposed parallel with the axis of the transmission unit and opening at one end through the left-hand end of the block 103 and at the other end opening to the valve chamber 115. Reciprocable in each cylinder 117 is a piston 118 which is operable in all positions to project from the left-hand end of the block 103. The motor cylinders, in the embodiment illustrated, correspond in number to the pump cylinders.

Operable in the valve chambers 110 and 115 are identical valves 120 and 121 of the wheel type described in Wahlmark Patent No. 2,474,706. Each valve is composed of a rim of radial width equal to the diameter of the cylinders, which rim has a close, fluid-tight but slid-

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ing fit between the end walls of the valve chamber in which it is located. The rim is connected to and carried by a hub through the medium of spokes which are spaced sufficiently apart so as to leave a plurality of openings through the valve and which also are of reduced thickness compared to the rim in order to permit a ready flow of fluid from one side of the valve to the other as well as circumferentially.

The valves 120 and 121 have a gyratory, as distinguished from a rotary, movement within the valve chamber, serving by such gyratory movement to connect the cylinders in rotational sequence alternately to the periphery of the respective valve chambers outwardly of the rim and to the chambers inwardly of the rim, the cylinders being completely closed at the time of reversal of the direction of movement of the corresponding piston. To impart such gyratory movement to the valve relative to the valve chambers the valves are given an eccentric mounting.

Completing the motor is a swash plate 125 comprising an outer annular member 126 positioned for constant engagement with the left-hand projecting ends of the motor pistons 118. The annular member 126 is carried by a plurality of thrust ball bearings 127.

It is believed apparent from the foregoing that the cylinder block 101 constitutes the driving part of the hydraulic transmission.

For rotating the cylinder block there is secured to the drive shaft 128 a spur gear 129 having teeth meshing with the teeth of a second spur gear 130 fixed to the cylinder block 101. The swash plate 125 carries thereon a gear 131 which meshes with a second gear 132 fixed to a driven shaft 133 for driving the alternator 134. Fixed upon the shaft 133 is a worm gear 135 which meshes with a worm 136 which through a right angle bevel gear system diagrammatically illustrated by the dashed line 137 serves to rotate the flyweights of a pair of centrifugal governors (hereinafter to be described in detail) which form a part of the control system of this invention.

Thus, as the drive shaft 128 is rotated, the cylinder block 101 is rotated through the medium of gears 129, 130. If the wobbler 100 is in neutral (vertical) position, the pump pistons 113 do not reciprocate thereby preventing the motor pistons 118 from reciprocating as the latter pistons bear against the face 126 of the swash plate, the swash plate is thereupon rotated at the same speed as the motor block and through the medium of gears 131 and 132 drives the output shaft at the same speed as the input shaft. When the wobbler 100 is moved away from the neutral position toward the position shown in Fig. 1, the pump pistons are caused to reciprocate thereby pumping fluid into the motor reciprocating the motor pistons. This reciprocation of the motor pistons, pushing outwardly against the inclined face 126 of the swash plate, serves to rotate the swash plate at a speed faster than the rate of rotation of the cylinder block. On the other hand, if the wobbler is moved counterclockwise from the position shown in Fig. 1 to beyond neutral position, the pump pistons are again caused to reciprocate but are in effect 180° out of phase with the motor pistons thereby causing the motor pistons to reciprocate in a manner permitting the swash plate to rotate at a speed less than the rotation of the cylinder block. At all input speeds, however, rotation of the cylinder block and hence the output shaft occurs.

For the purpose of tilting the wobbler 100 there is provided a speed control 11 including a pair of cylinders 12 and 13 in which pistons 14 and 15 are reciprocable. The pistons are connected to a lever 16, in turn fixed to the wobbler 100 so that motion of the pistons is imparted to the lever for the purpose of adjusting the inclination of the wobbler.

Fluid under pressure for reciprocating the pistons 14 and 15 is derived from a source including a pair of pumps 20 and 21 discharging fluid under pressure into

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a common conduit 22 communicating with a filter 23. A branch conduit 24 connects the filter to the interior of the transmission 10 for make-up purposes and the like, while a second branch conduit 25 directs fluid under pressure directly to a primary governor 26 and through a branch conduit 27 to a secondary governor 28.

The primary governor 26 includes a plurality of fly weights 30 operable upon rotation to move a pilot valve 31 to positions directing fluid under pressure from the conduit 25 into passages 32 and 33, which communicate respectively with the cylinders 12 and 13, or to connect either of said passages to a drain 34. The centrifugal force of the fly weights 30 is opposed by a speeder spring 35, with the tension of the spring being adjustable through the medium of a rack and pinion device 36.

It will be noted that there is provided in the passage 33 a trip valve 30 whose purpose it is to dump the pressure in the portion of passage 33 adjacent the cylinder 13 (indicated as 33a) and hence reduce the pressure in the cylinder 13. The reduction of pressure in the cylinder 13 permits the natural moment of the wobbler to move it toward under-drive position with such motion of the wobbler being accompanied by movement of the pistons 14 and 15 to the right (as seen in Fig. 1).

In the normal operation of the apparatus thus far described, the primary governor 26 is driven through the medium of a gear 37 by the output of the transmission and thus senses the output speed of the transmission to the end that speeds below a desired constant speed cause the pilot valve 31 to be moved to a position directing fluid under pressure into the passage 33 and hence into the cylinder 13. Simultaneously the passage 32 will be placed into communication with the drain line 34 through the medium of drilled passages 38 and 39 in the spool valve. As a result the pistons 14 and 15 will be moved to the left (as seen in Fig. 1), tilting the wobbler in a direction to increase the output of the pump. Conversely, should the transmission output exceed a predetermined desired speed the spool valve will be moved to a position connecting the passage 32 to the source while connecting the passage 33 to drain so that the pressure in the cylinder 12, coupled with the natural moment of the wobbler tending to move it to underspeed position, will cause the wobbler to move in a direction reducing the output of the pump.

It has now been found desirable to incorporate certain safety features in the foregoing system for the purpose of causing the transmission to "fail-safe" in the event of malfunction of the control just described. To this end there is interposed in the passage 33 the trip valve 40 operable under the control of the secondary governor 28 to prevent the pressure in the passage 33 from being transmitted to the cylinder 13 and simultaneously to reduce the pressure in said cylinder so that the natural moment of the wobbler may cause it to move to underspeed position. This result is achieved even though the pilot valve 31, under the control of the primary governor, is in a position which would otherwise move the wobbler in a direction increasing pump output.

For this purpose the trip valve 40 comprises a casing 41 having therein a bore 42 in which a spool valve 43 is reciprocable. The passage 33 is connected into the bore by means of an annular port 44 while that portion of the passageway 33 (identified as 33a) which intervenes between the trip valve and the piston 13 is connected to the interior of the bore by a port 45. The right hand end of the bore 42 is connected to drain by a port 46. The valve 43 is urged by a spring 47 to a position moving the land 48 to the left of the port 45, so as to establish communication between the passage portion 33a (and hence the cylinder 13) with the drain 46. To move the valve 43 to a position establishing communication between the passage portions 33 and 33a through the medium of the ports 44 and 45 the valve is provided with a piston portion 49 reciprocable in a cylinder 50 formed in one

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end of the bore 42 to which cylinder a passage 51 opens. Fluid under pressure supplied by the passage 51 serves to move the valve 43 to the position illustrated, permitting normal operation of the transmission under the control of the primary or basic governor 26. The secondary governor 28, however, is effective to dump the pressure in the passage 51 to permit the spring 47 to shift the valve so as to cause the transmission to move to under speed position independently of the reaction of the basic governor 26.

Referring to Fig. 2 it will be seen that the secondary governor 28 comprises a casing 60 having a sleeve 61 rotatably mounted therein to be driven by driveshaft 62. A cuplike member 63 is secured to the end of the sleeve and surrounds pivotally supported fly weights 64 which are connected to a valve 65, so that outward movement of the fly weights under the influence of centrifugal force serves to move the valve 65 to the left (as seen in Fig. 2) against the bias of a speeder spring 66. Communicating with a bore 67 of the valve is a port 68 connected to the branch conduit 27 while a port 69 connects with the passage 51. A port 70 connects to a drain passage 71 as does a second port 72 formed in the right hand end of the bore. An additional port 73 connects to a passage 74, in turn connected to a pressure switch 75 which switch may be utilized to establish suitable electric connection to an alternator driven by the transmission when the latter has attained a predetermined minimum speed.

The valve 65 is provided with cross passages 76 and 77 for the purpose of establishing connection between the various ports when the valve is in different positions.

When the valve 65 is in the position illustrated in Fig. 2 (normal position) fluid under pressure in the passage 27 is directed through the port 68, cross passage 76 to port 69 which communicates with passage 51 opening into the cylinder 50 thus to move and maintain the trip valve 40 in the normal position illustrated in Fig. 1.

With the secondary governor 28 in the position illustrated in Fig. 2, the speed of the transmission is under the control of the primary or basic governor 26. Should there be a failure in the drive system of the basic governor, such as the breakage of a driveshaft or the like, which would cause the basic governor to lose speed or even stop, its valve would be moved to a position calling for increased transmission output speed and thus would seek to direct fluid under pressure through the passage 33 into the cylinder 13. Under these conditions the transmission could speed to destruction if the failure were confined to the basic governor drive and not to the transmission. In the embodiment of the invention illustrated, the secondary governor 28 is driven by means of a gear 78 receiving its power from the same source as the gear 27 so that under the emergency conditions just described the secondary governor would also stop whereupon its speeder spring 66 would move the valve 65 to the position illustrated in Fig. 3, wherein it will be noted that the passage 51 is connected by means of the port 69 to the port 70 and passage 71 and thus the pressure within the cylinder 50 is reduced to the point where the spring 47 is sufficient to shift the trip valve to a position connecting the passage portion 33a to the drain 46. When this situation obtains, the transmission is moved to under-drive or under-speed position. In addition, the pressure switch port 73 is connected by the port 82 to passage 83 and hence to case or drain. Resulting operation of the pressure switch will disconnect the particular alternator involved from the load bus.

On the other hand, should there be a failure of the primary governor control causing the transmission to over-speed by reason of a failure other than a breakage in the drive train to the governor the increased speed of rotation of the fly weights 64 will move the valve 65 to the position illustrated in Fig. 4 wherein the pressure conduit 27, is through the medium of the port 68, connected directly with the right hand end of the bore 67. The

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passage 51 is connected through the cross passage 77 to the drain port 82 which drain through the drilled passages 83 and 84 in the valve stem. With the valve in the position of Fig. 4 the pressure in the cylinder 50 is similarly reduced so as to dump the pressure in the cylinder 13 to cause the transmission to move into under-drive operation.

Inasmuch as the pressure generated by the pumps 20 and 21 is utilized for purposes in addition to control, means are provided in the secondary governor valve for preventing loss of pressure when that valve is in the position of Fig. 4. For this purpose an orifice-forming member in the form of a piston 90 is slidable in the bore and normally urged by a spring 91 to the position illustrated in Figs. 2 and 3, wherein openings 92 in the member 90 register with the drain port 72. Thus, normal leakage in the bore may be drained without obstruction.

When the pressure port 68 communicates directly with the end of the bore, as illustrated in Fig. 4, such pressure serves to move the member 90 to the position shown in that figure wherein the registry between the openings 92 and the port 72 is but a slight overlap, thereby forming an orifice to maintain the pressure in the passage 27. If desired, the port 72 may be closed completely (except for leakage) by the foregoing movement of the member 90 similarly to maintain the pressure in passage 27.

From the foregoing description it will be apparent to those skilled in the art that there has been provided a hydraulic control system for controlling the speed of an apparatus which is particularly adapted for use in installations wherein speed is sensed by a fly ball governor and the system of the invention is capable of causing the apparatus to reduce speed upon departure of the apparatus from a normal operating speed range.

I claim:

1. A control means for an apparatus of the character described comprising a source of control fluid under pressure, a speed control movable by fluid under pressure to vary the speed of the apparatus, a first fluid pressure control means responsive to the speed of the apparatus, a first passage connecting the source to the first fluid pressure control, a second passage connecting the first fluid pressure control means to the speed control, a valve controlling one of the passages, fluid pressure operated means for holding the valve in a first position permitting the transmission of fluid pressure in said one passage, means biasing the valve toward movement to a second position dumping the pressure in said one passage, a second fluid pressure control means connected to said source and to a passageway communicating with said fluid pressure operated means, means connecting said second fluid pressure control means to the apparatus to sense the speed of the apparatus and said second fluid pressure control means being operative to direct fluid under pressure into said passageway to move the valve to said first position only when the apparatus is operating within a predetermined speed range and to relieve the pressure in said passageway to permit the valve to move to said second position when the apparatus is operating at speeds above said range or when the second fluid pressure control means senses no speed of said apparatus.

2. A control for an apparatus of the character described having a rotatable output shaft comprising a governor connected to the output shaft to be driven by the apparatus, a source of control fluid under pressure, a speed control movable by fluid under pressure to vary the speed of the apparatus, a first governor valve operated by said governor and controlling a fluid connection between the source and said speed control, said governor valve being operative to vary the fluid pressure delivered to the speed control in accordance with the speed of the apparatus to maintain said speed substantially constant, a second governor driven by the output shaft of the apparatus, a second governor valve operated by the second governor, means including a fluid circuit controlled by

the second governor valve for reducing the pressure applied to the speed control independently of the operation of the first governor valve, said second governor valve being movable by the second governor with rotation of said shaft from a first position reducing the pressure applied to the speed control, to a second position wherein the pressure applied to the speed control is governed by the first governor valve, to a third position reducing the pressure applied to the speed control.

3. A control for an apparatus of the character described comprising a source of control fluid under pressure, a speed control movable by control fluid under pressure to vary the speed of the apparatus, a fluid circuit interconnecting the speed control and the source including a first valve operable to vary the control fluid pressure delivered to the speed control and a second valve movable sequentially from a first position in which the control fluid pressure in the circuit is dumped to a second position in which said control fluid pressure in the circuit is unaffected to a third position in which the control fluid pressure in the circuit is dumped, means constantly biasing the valve to said first position a first governor driven by the apparatus and connected to operate the first valve, and a second governor driven by the apparatus and connected to move the second valve against said biasing means to said second position during operation of the apparatus at normal speeds and to move the second valve to the third position when the speed of the apparatus exceeds said normal speed, with said biasing means serving to move said second valve to said first position when said second governor is at rest.

4. In a hydraulic pressure operated system for controlling the speed of an apparatus, having a governor, drive means connecting the governor to be driven by the apparatus and a governor operated valve for varying said pressure in response to departures from a predetermined speed, a fail-safe control comprising a second governor connected to be driven by said drive means, a second valve connected to be moved by the second governor sequentially from a first to a second and then to a third position as the speed of the second governor increases

from an underspeed to a normal speed then exceeds the normal speed, said second valve in said first and third positions serving to vary said pressure in a manner tending to reduce said speed and in the second position being ineffective to vary said pressure.

5. The apparatus of claim 4 in which said second valve includes a casing having a bore therein, a pressure port opening into the bore, a drain port at one end of the bore, and a valving member slidable in the bore and controlling the ports, said second valve in the third position establishing communication through the bore between said pressure port and the drain port, and including an orifice-forming member slidable in said end of the bore and movable by fluid pressure therein when the valve is in the third position to a position at least partially covering the drain port to reduce the flow therethrough.

6. A pressure relieving valve for use in a fluid pressure system comprising a valve casing having a bore therein, a pressure port and an outlet port opening into the bore, a drain port at one end of the bore, a valving member slidable in the bore and controlling communication between the ports, said valving member being slidable in the bore from a position establishing communication between the pressure port and the outlet port, to another position establishing communication through the bore between the pressure port and the drain port, a piston unconnected to the valving member and slidable in said end of the bore by fluid pressure therein when the valve is in said other position to a position at least partially covering the drain port to throttle the same thereby to reduce the flow therethrough.

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