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HYDRAULIC SYSTEM FOR ADJUSTABLE PITCH AERONAUTICAL PROPELLER

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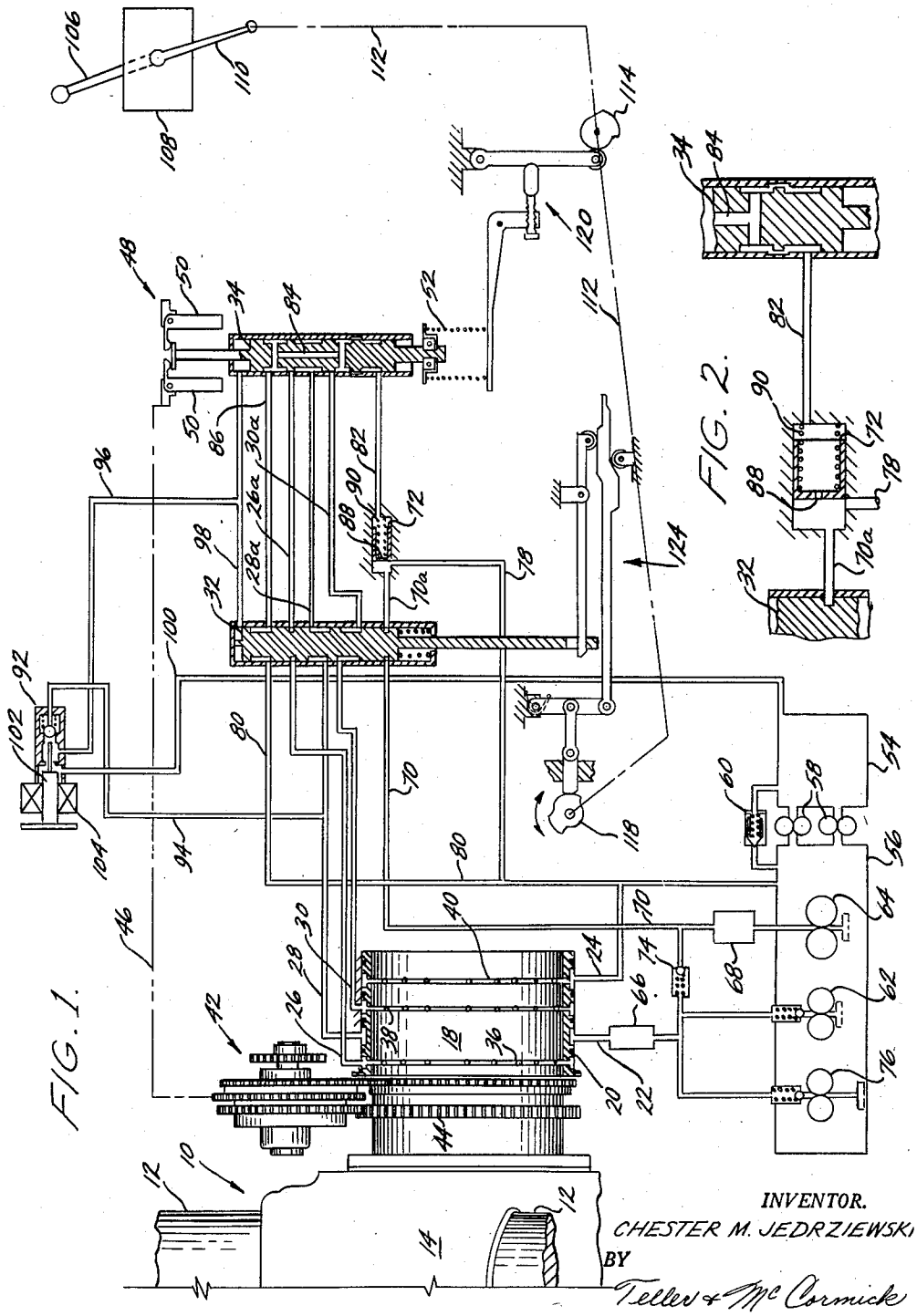


FIG. 1.

FIG. 2.

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HYDRAULIC SYSTEM FOR ADJUSTABLE PITCH AERONAUTICAL PROPELLER

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5 Claims. (Cl. 170—160.2)

This invention relates to an adjustable pitch aeronautical propeller and, more specifically, to an improved hydraulic system for controlling the propeller pitch.

It is the general object of the invention to provide for an aeronautical propeller having an hydraulic pitch changing mechanism an hydraulic system which includes a source of hydraulic fluid under pressure and continuously operating main pump means for supplying the pitch changing mechanism and which also includes supplemental pump means and flow control means associated therewith which are adapted to join with the main pump means in supplying the pitch changing mechanism when a pitch change is being effected.

The drawing shows a preferred embodiment of the invention and such embodiment will be described, but it will be understood that various changes may be made from the construction disclosed, and that the drawing and description are not to be construed as defining or limiting the scope of the invention, the claims forming a part of this specification being relied upon for that purpose.

Of the drawing,

Fig. 1 is a schematic view of an aeronautical propeller and the hydraulic system provided therefor in accordance with the present invention; and

Fig. 2 is an enlarged view of the valve means forming a part of the aforesaid system and which is employed to control flow from standby or supplemental pump means also forming a part of the system.

The reference numeral **10** designates generally a propeller assembly which includes a plurality of adjustable pitch blades **12**, **12** and a hub **14** having a nose section (not shown). The propeller assembly **10** also includes a conventional pitch changing mechanism in the form of an hydraulic motor which comprises a cylinder in the nose section and a piston movable within the cylinder responsive to hydraulic pressure introduced to the cylinder on either side of the piston. Thus, the piston is reciprocable within the cylinder and can be moved selectively therein. By means of cam slots and cam rollers, rectilinear movement of the piston within the cylinder rotates a gear within the hub **14**, the said gear being engaged by gears or segments on the inner ends of the propeller blades **12**, **12** whereby to change the pitch of the blades by rotating them on their generally longitudinal pitch change axes. Thus, movement of the piston within the cylinder in one direction is employed to effect a change in the pitch angle toward high pitch and movement of the piston in the opposite direction is used to effect a change toward low pitch. An hydraulic motor type pitch changing mechanism is shown in the Anderson Patent 2,653,668 and there is a further showing and description of an hydraulic motor of the type mentioned in the Pearl Patent No. 2,703,148 to which reference may be had. Pitch changing mechanism of this type is used to feather the propeller blades and to reverse their pitch as well as to effect the more routine pitch adjustments.

Obviously, an hydraulic motor of the aforedescribed type can be operated if means are provided to route hydraulic fluid under pressure selectively to one side or to the other side of the motor piston while connecting the opposite side to drain. Such means can be considered as part of the pitch changing mechanism or it can be considered as part of an hydraulic control system for the said mechanism. While means adapted to function in the aforedescribed way may take various forms, the exemplary means used in the system to be described comprises a transfer bearing having an inner ring or section **18** which rotates with the propeller assembly **10** and an outer ring or section **20** which does not rotate but which embraces the said inner ring.

It will be observed that a plurality of conduits **22**, **24**, **26** **28** and **30** are connected to the outer, non-rotatable section **20** of the transfer bearing. The conduit **22** communicates with a source of hydraulic fluid under pressure as will be described hereinafter, but it does not introduce the hydraulic fluid to the pitch changing mechanism. That is, the bearing section **20** is constructed and arranged to connect the conduit **22** with the conduit **28** which extends to a feathering valve **32**. Thus, fluid at source or pump pressure is directed to the feathering valve before it is introduced to the pitch changing mechanism. The feathering valve **32** is normally positioned as shown in the drawing to pass the fluid from the conduit **28** to a conduit **28***a* and on to a pilot or control valve **34**. The pilot valve operates to pass the fluid at pump pressure from the conduit **28***a* to a conduit **26***a* or to a conduit **30***a* which respectively communicate at the feathering valve **32** with the conduits **26** and **30**.

The conduit **26** at the transfer bearing communicates through the non-rotatable section **20** with an annular port **36** in the rotatable section **18** and the conduit **30** at the transfer bearing communicates through the non-rotatable section with an annular port **38** in the rotatable section. The ports **36** and **38** are respectively connected with passage means (not shown) extending to opposite sides of the piston in the hydraulic motor, the arrangement being such that when pressurized hydraulic fluid is introduced through the port **36** from the conduit **26**, the blade angle is corrected toward low pitch and when hydraulic fluid is introduced under pressure through the passage **38** from the conduit **30**, the blade angle is changed toward high pitch. Accordingly, the conduit **26** can be called a low pitch inlet conduit for the pitch changing mechanism and the conduit **30** can be called a high pitch inlet therefor. The rotatable bearing section **18** has another annular port **40** which receives hydraulic fluid under drain pressure from the hydraulic motor, this port being connected with the conduit **24** which extends to a main drain conduit to be described.

As its name would imply, the feathering valve **32** is operated only to connect the pump conduit **28** with the high pitch conduit **30** in a feathering operation. At all other times, the feathering valve **32** remains in the position shown in Fig. 1 whereby to effect communication between the low pitch conduit **26** and the conduit **26***a* extending to the pilot valve **34**; between the pump conduit **28** and the conduit **28***a* extending to the pilot valve; and between the high pitch conduit **30** and a conduit **30***a* extending to the pilot valve. Only the pilot valve **34** is moved to effect selective connection between the pump conduit and the low and high pitch conduits, respectively, to bring about all pitch changes except the change to "feathering." The pilot or control valve **34** can be moved either by automatic speed responsive mechanism or by manually actuated mechanism. At this point, only the automatically operable speed responsive mechanism will be described.

The said automatically operable mechanism is responsive to propeller speed and is driven by the propeller. More specifically, a differential gear unit indi-

cated generally at 42 is arranged to be driven by a gear 44 which is rotatable with the propeller assembly 10 and the differential unit 42 is connected as indicated schematically by the line 46 with the speed responsive mechanism 48 which controls the position of the pilot valve 34. The flyweights 50, 50 forming a part of the mechanism 48 are arranged to be thrown outwardly by centrifugal force during rotation of the propeller assembly and to bear against the valve 34 thrusting it downwardly. The greater the propeller speed, the farther downwardly the valve 34 will be thrust. When the pilot valve is thrust downwardly, it effects a connection between the pump conduit 28*a* and the high pitch conduit 30*a* whereby the pitch changing mechanism is operated to effect a change toward high pitch which reduces propeller speed. If the propeller speed is low, the flyweights 50, 50 will be retracted and the pilot valve 34 will be thrust upwardly by a spring 52 engaging the bottom of the pilot valve. When the pilot valve is thrust upwardly as is best shown in Fig. 3, it connects the pump conduit 28*a* with the low pitch conduit 26*a* whereby the pitch changing mechanism is operated to effect a change toward low pitch which will increase propeller speed.

Referring now to the hydraulic system in greater detail, it will be seen that the source of pressurized hydraulic fluid includes an atmospheric sump 54 and a pressurized sump 56. Hydraulic fluid is transferred from the atmospheric sump 54 and introduced under pressure to the pressurized sump 56 by one or more pumps 58, 58. A relief valve 60 is located in a conduit between the pressurized sump and the atmospheric sump to drain fluid from the pressurized sump into the atmospheric sump when necessary.

The hydraulic fluid is withdrawn from the pressurized sump 56 and introduced to the system under additional pressure by means of a main pump 62 and standby pump 64. The main pump and the standby pump are preferably driven by the propeller and to this end a driving connection (not shown) can be effected between the differential gearing 42 and the said pumps. Normally, only the main pump 62 supplies hydraulic fluid to the conduit 22 through a filter 66 and the standby pump 64 pumps the fluid through a filter 68 into a conduit 70. The conduit 70 extends to the feathering valve 32 and normally communicates therethrough with a conduit 70*a* which extends to a standby valve 72. However, when the passage 70 is blocked at the feathering valve 32, the increased pressure in the conduit 70 will open a check valve 74 causing flow from the standby pump 64 to enter the transfer bearing conduit 22 through the filter 66. During periods when the propeller is not driven, the hydraulic system can be employed to operate the pitch changing mechanism by means of a motor-driven auxiliary pump 76 which passes the hydraulic fluid through the filter 66 into the transfer bearing pump inlet conduit 22, the main pumps 62 and 64 not being in operation.

As previously mentioned, during normal propeller operation when only routine pitch changes are required, the feathering valve 32 is positioned as shown in Fig. 1 of the drawings. In such position of the feathering valve, hydraulic fluid at pump pressure from the source passes through the transfer bearing into the conduit 28 which extends to the feathering valve and there communicates with the conduit 28*a* extending to the pilot valve. When there is no pitch change required, the pilot valve 34 will be positioned to block the end of the conduit 28*a*. Under the aforesaid conditions of operation, the hydraulic fluid pumped by the standby pump 64 through the conduit 70 and the feathering valve 32 is returned to the pressurized sump through the normally open standby valve 72 and a conduit 78 and a main drain conduit 80. Also, under the aforesaid conditions, there is no hydraulic flow in the conduits 26 and 30 extending from the feathering valve to the transfer bearing. That is, the feathering valve 32 is positioned to prevent flow from the pump conduit 28 into either of the conduits 26 or 30 and the pilot valve 34 is positioned to prevent flow from the conduit 28*a* into either of the conduits 26*a* or 30*a*.

However, there will be some flow through the pilot valve 34. That is, a conduit 82 extending from the standby valve 72 communicates through an internal passage 84 in the pilot valve 34 with a conduit 86 extending between the said pilot valve and the feathering valve 32. At the feathering valve 32, the conduit 86 communicates with the main drain conduit 80. The aforesaid flow from the conduit 82 through the pilot valve to drain comes from the standby valve 72 which is connected to the standby pump conduit 70*a*. Most of the fluid from the standby pump conduit is drained in the valve 72 through the conduit 78 as described, but some of the flow passes to the conduit 82 and to the pilot valve through a small aperture 88 provided in the said standby valve. Whenever the pilot valve 34 is moved upwardly or downwardly, it blocks flow between the conduit 82 and the internal passage 84. With the internal passage 84 blocked, the pressure will build up in the conduit 82 until it is substantially equal to the pressure in the conduit 70*a*. Under these pressure conditions, the standby valve spring 90 will close the standby valve 72 whereby standby pressure will increase in the conduits 70 and 82 to the point where the standby check valve 74 opens. Then, flow from the standby pump 64 will pass through the main filter 66 to the transfer bearing with flow from the main pump 62.

From the foregoing description it will be understood that the hydraulic supply system provided in accordance with this invention has a continuously operating main supply and a continuously operating supplemental supply which is used with the main supply to effect pitch changes. That is, the main pump 62 is connected with the supply conduit 22 and the conduit 22 through the normally open feathering valve 32 to the control valve 34. The control valve normally closes the supply conduit, but it is movable to open the supply conduit for communication with the pitch changing mechanism through the conduits 26 or 30. The standby pump is connected with a first conduit 70 and through the normally open feathering valve 32 to a drain 78 and 80. A normally open, pressure responsive valve 72 is disposed between the first conduit and the drain and has bleed passage means accepting some flow from the first conduit to drain through the passage 84 in the normally closed control valve 34. However, whenever the control valve is opened, the bleed passage is closed to increase pressure in the normally open, pressure responsive standby valve 72 which will cause it to close to increase pressure in the first conduit 70. Pressure can also be increased in the said first conduit by operating the feathering valve. In either event, the increased pressure will open the pressure responsive normally closed check valve 74 in a second conduit which interconnects the first conduit 70 and the supply conduit 22. Obviously, the increased pressure condition occurs only when a pitch change is called for by movement of the feathering valve 32 or the control valve 34 from their normal positions shown in Fig. 1 of the drawing.

Propeller feathering can be effected by hydraulic actuation of the feathering valve 32 and/or the pilot valve 34 or feathering can be effected by manual or automatic operation of mechanical means for actuating the feathering valve or feathering can be effected by simultaneous operation of the hydraulic and the mechanical valve actuating means. The hydraulic actuating means includes a normally closed check valve 92 which is connected between a conduit 94 extending from the pump conduit 28 and a conduit 96 extending to a conduit 98

which interconnects the top ends of the chambers for the feathering and control valves 32 and 34. A drain conduit 100 also extends from the check valve 92 to the atmospheric sump 54. The check valve construction includes an armature 102 which can be moved from the normal position shown in the drawing toward the right either manually or by influence of a solenoid coil 104 to close the drain passage 100 and to open the ball check whereby to effect communication between the conduits 94 and 96. This will cause hydraulic fluid at pump pressure to flow to the chambers at the tops of the feathering valve 32 and the pilot or control valve 34, forcing the said valves downwardly. Movement of the feathering valve downwardly interconnects the pump conduit 28 with the high pitch conduit 30 as shown in Fig. 2 and the propeller will change pitch through the high pitch range into full feather as long as hydraulic pressure holds the feathering valve down.

Movement of the pilot valve 34 downwardly is of no effect as long as the feathering valve is moved downwardly as described, but if the feathering valve sticks in the normal "up" position, such movement of the pilot valve by hydraulic pressure will effect feathering. That is, when the pilot valve is thrust downwardly, the conduits 28*a* and 30*a* are interconnected and if the feathering valve is in its normal position the flow will be through the feathering valve to the transfer bearing to effect a high pitch change to the full feather position as long as the pilot valve is held down by hydraulic pressure.

The mechanical means for actuating the feathering valve 32 includes a power lever 106 which is connected through a coordinator 108 with a crank 110 which in turn is connected through suitable motion transmitting means indicated schematically by the line 112 with a plurality of rotatable cams 114 and 118. The power lever 106 is the main control device operated by the pilot or flight engineer to control propeller pitch through the complete range of propeller operation. That is, the power lever is selectively positioned to call for a desired pitch or propeller speed, and in being moved from one position to another the cams 114 and 118 are rotated to operate the control valve 34 and the feathering valve 32, respectively. The cam 114 acts upon valve actuating means in the form of motion transmitting linkage mechanism indicated generally at 120 to control the effective force of the spring 52 on the pilot valve 34. The cam 118 operates a motion transmitting linkage mechanism indicated generally at 124 which is engaged with the feathering valve 32.

A detailed description and explanation of operation of the valve actuating mechanism is unnecessary for an understanding of the present invention. Briefly, the actuating mechanism 120 for the control valve or pilot valve 34 when operated by the power lever 106 through the cam 114 varies the force of the spring 52 whereby to set up a valve force worked against by the speed responsive valve operating mechanism 48. That is, if the valve spring 52 is forced upwardly, a higher propeller speed is needed to place the pilot valve in its normal or neutral position. If the mechanism 120 exerts less force on the valve spring 52, the pilot valve will be neutralized or disposed in a normal position at a reduced propeller speed.

The actuating mechanism 124 for the feathering valve is operated by the cam 118 only for the purpose of pulling the feathering valve downwardly whereby to effect a change through the high pitch range into the feathered position of the propeller. Obviously, the actuating mechanism 124 can be operated by means other than the power lever and cam for the same purpose. Such means can be engine operated automatically to feather the propeller under negative torque conditions wherein engine power fails or is sharply reduced.

The principal advantage afforded in accordance with the present invention resides in the provision of means for supplementing the normal supply flow with flow from the standby pump whenever either the feathering valve or the control valve is operated to effect a pitch change.

The invention claimed is:

1. A supply system for an aeronautical propeller having hydraulic pitch changing mechanism and comprising, a source of hydraulic fluid under pressure, a supply conduit connected with said source, a control valve connected between said supply conduit and said pitch changing mechanism and having a closed position and an open position to control flow therebetween, a standby pump connectible with a source of hydraulic fluid, a first conduit connected to said standby pump, a drain conduit external of said control valve, a normally open pressure responsive valve disposed between said first conduit and said drain conduit and having bleed passage means connecting said first conduit and the control valve, the control valve having means connecting said bleed passage means and the drain conduit in only the closed position of the control valve whereby movement of the control valve to open position closes said bleed passage means to increase pressure therein and to close the said normally open valve and thereby to increase pressure in said first conduit, a second conduit interconnecting said first conduit and said supply conduit, and a pressure responsive normally closed valve in said second conduit adapted to open in response to the increased pressure in said first conduit whereby to supplement the supply by flow from said standby pump.

2. A supply system for an aeronautical propeller having hydraulic pitch changing mechanism and comprising, a main pump connectible with a source of hydraulic fluid, a supply conduit connected with said main pump, a control valve connected between said supply conduit and the pitch changing mechanism and having a closed position and an open position to control flow therebetween, a standby pump connectible with said source, a first conduit connected to said standby pump, a drain conduit external of the control valve, a normally open pressure responsive valve disposed between said first conduit and said drain conduit and having bleed passage means connecting said first conduit and the control valve, the control valve having means connecting said bleed passage means and the drain conduit in only the closed position of the control valve whereby movement of the control valve to open position closes said bleed passage means to increase pressure therein and to close said normally open valve and thereby to increase pressure in said first conduit, a second conduit interconnecting said first conduit and said supply conduit, and a pressure responsive normally closed valve in said second conduit adapted to open in response to the increased pressure in said first conduit whereby to supplement the main pump supply with supply from said standby pump when said control valve is moved to open position to effect a pitch change.

3. A supply system for an aeronautical propeller having hydraulic pitch changing mechanism and comprising, a source of hydraulic fluid under pressure, a supply conduit connected with said source, a feathering valve disposed in said supply conduit normally to permit flow therethrough but movable to a feathering position, a control valve connected between said supply conduit and the pitch changing mechanism and having a closed position and an open position to control flow therebetween, a standby pump connectible with a source of hydraulic fluid, a first conduit connected to said standby pump, the said feathering valve being also disposed in said first conduit and normally positioned to permit flow therethrough but preventing flow therethrough when moved to its feathering position whereby to increase pressure in said first conduit, a drain, a normally open pressure responsive valve disposed between said first conduit and said drain and having bleed passage means connecting said first conduit and the control valve, the control valve having means connecting said bleed passage means and the drain in only the closed position of the control valve

whereby movement of the control valve to open position closes said bleed passage means to increase pressure therein and to close said normally open valve and thereby to increase pressure in said first conduit, a second conduit interconnecting said first conduit and said supply conduit, and a pressure responsive normally closed valve in said second conduit adapted to open in response to the increased pressure in said first conduit whereby to supplement the supply by flow from said standby pump.

4. A supply system for an aeronautical propeller having hydraulic pitch changing mechanism and comprising, a main pump connectible with a source of hydraulic fluid, a supply conduit connected with said main pump, a feathering valve disposed in said supply conduit normally to permit flow therethrough but movable to a feathering position, a control valve connected between said supply conduit and the pitch changing mechanism and having a closed position and an open position to control flow therebetween, a standby pump connectible with said source, a first conduit connected to said standby pump, the said feathering valve being also disposed in said first conduit and normally permitting flow therethrough but adapted to close said first conduit whereby to increase pressure therein when moved to its feathering position, a drain, a normally open pressure responsive valve disposed between said first conduit and said drain and having bleed passage means connecting said first conduit and the control valve, the control valve having means connecting said bleed passage means and the drain in only the closed position of the control valve whereby movement of the control valve to open position closes said bleed passage means to increase pressure therein and to close said normally open valve and thereby to increase pressure in said first conduit, a second conduit interconnecting said first conduit and said supply conduit, and a pressure responsive normally closed valve in said second conduit adapted to open in response to the increased pressure in said first conduit whereby to supplement the main pump supply with supply from said standby pump.

5. A supply system for an aeronautical propeller having hydraulic pitch changing mechanism and comprising, a source of hydraulic fluid under pressure, a supply conduit connected with said source, a feathering valve disposed in said supply conduit normally to permit flow therethrough but movable to a feathering position, a control valve connected between said supply conduit and the pitch changing mechanism and having a closed position and an open position to control flow therebetween, a standby pump connectible with a source of hydraulic fluid, a first conduit connected to said standby pump, the said feathering valve being also disposed in said first conduit and normally positioned to permit flow therethrough but preventing flow therethrough when moved to its feathering position whereby to increase pressure in said first conduit, a drain, a normally open pressure responsive valve disposed between said first conduit and said drain and having bleed passage means connected with said drain, the control valve being adapted to close said bleed passage means in the open position of the control valve whereby to cause said normally open pressure responsive valve to close and to increase pressure in said first conduit, a second conduit interconnecting said first conduit and said supply conduit, and a pressure responsive normally closed valve in said second conduit adapted to open in response to the increased pressure in said first conduit whereby to supplement the supply by flow from said standby pump.

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