HYDRAULIC SYSTEM FOR STEAM TURBINE

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This invention relates generally to a hydraulic system for supplying liquid under pressure to a machine and more specifically to an improved system in a steam turbine for supplying high pressure oil for operating auxiliary hydraulic systems such as a governing system, and low pressure oil for lubrication. This is a division of my copending application entitled "Hydraulic System for Steam Turbine," Serial Number 390,472, filed November 6, 1953.

It has heretofore been proposed to supply high and low pressure oil to a prime mover such as a steam turbine by providing a main centrifugal pump directly coupled to the prime mover shaft. A portion of the discharge from the main pump which is at a high pressure is supplied to the governing system of the turbine and to a hydraulic turbine; the remainder of the discharge of the main pump is bypassed around the hydraulic turbine and passes through pressure reducing means to an oil cooler and then supplied to bearings of the prime mover. The hydraulic turbine derives its energy from the pressure differential between the high pressure intake from the main pump and low pressure discharge of oil from the hydraulic turbine. A low pressure pump is directly connected to and driven by the hydraulic turbine. The low pressure pump takes suction from a reservoir and discharges to the intake of the main pump. The nature of the present invention resides in the provision of an improved hydraulic system for steam turbines whereby some of the high pressure fluid supplied by the main pump to the hydraulic turbine, bypasses the hydraulic turbine to pass through pressure reducing means for low pressure bearing lubrication. Instead, the discharge of the low pressure pump is utilized for bearing lubrication with the hydraulic turbine discharging to the intake of the main pump. Therefore, more of the energy derived from the drop in pressure from the high pressure produced by the main pump to the low pressure required for lubrication, is utilized to operate the hydraulic turbine and low pressure pump, and none of this energy is wastefully dissipated by bypassing the hydraulic turbine and throttling for lubrication purposes as has heretofore been done.

It is therefore an object of the present invention to more efficiently utilize the available energy represented by the pressure drop between the high value required for the governing system and hydraulic turbine and the low value required for lubrication.

Another object of the invention is to provide a system for supplying liquid to a machine at two different pressures that are more economical than prior known systems.

Another object of the invention is to require smaller piping to and from the main turbine pedestal than has heretofore been used in prior known systems.

Another object of the invention is to provide an improved dual fluid system for supplying liquid to a machine at two different pressures.

Objects and advantages other than those set forth above will be apparent from the following description when read in connection with the accompanying drawing, in which a diagrammatic view is shown, partly in section, of a system embodying the invention.

5 Referring to the drawing, this invention is illustrated as applied to a machine such as a steam turbine indicated generally at 1 and having a shaft 2, a lubrication system including a bearing 3 to which oil is supplied under pressure, and a servomotor indicated generally at 4 in the governing system to which oil is supplied under pressure through a conduit 5. As is well known, the governor is arranged to control a servomotor which may be in the form of a piston 6 slidably arranged in a cylinder 7, for positioning a turbine inlet control valve 8. Motive fluid is supplied to the turbine 1 through an inlet conduit and the speed and output of the turbine are controlled by regulation of the valve 8 through the servomotor 4. Any other suitable known type of governing system for turbines may be substituted for the servomotor 4.

A liquid, which may be oil for lubricating the turbine and a second liquid which may be water or another non-inflammable liquid for actuating the governing system, is supplied from a reservoir 12, which is customarily located at a level below the turbine 1 so that the oil supplied to the bearings and other components may conveniently be drained back to the reservoir 12 by gravity. The oil for lubricating the turbine may be a petroleum product or any other suitable known liquid having lubricating properties. In the drawing the turbine lubrication system is drained by means of a conduit 13 into two hydraulically independent compartments, one 12a for the high pressure system utilizing a non-inflammable liquid, and another 12b for the low pressure system that utilizes oil.

In accordance with the invention, a main pump, indicated generally at 14, may be driven by any suitable prime mover but is preferably directly coupled to an extension 16 of the turbine shaft 2. This main pump 14 has an impeller, not shown, mounted directly on the turbine shaft extension 16. The pump is enclosed by a casing 17 which defines an annular pump inlet 18 and a discharge scroll 21. Any suitable type of pump other than a centrifugal pump may also be employed.

The discharge scroll 21 of the pump 14 communicates with a discharge pipe 22, to which is connected the servomotor supply conduit 5. A suitable pressure regulating valve 23 may be incorporated in the conduit 5 to maintain the pressure of the liquid supplied to the servomotor 4 constant at a preselected value. Spent liquid from the servomotor 4 returns through conduit 24 to the inlet 18 of pump 14, as noted hereinafter. A suitable check valve 25 is provided in conduit 22 to prevent flow of liquid in a reverse direction through pump 14.

Arranged in the liquid reservoir 12a or in any other suitable location is a hydraulic turbine 26 consisting of a housing 27, an impeller, not shown, and an inlet scroll 31. A conduit 32 supplies liquid under pressure from the discharge scroll 21 of pump 14 to the inlet scroll 31 of turbine 26. Liquid discharge from the turbine 26 is led by a conduit 33 to the inlet 18 of the main pump 14. The shaft 34 of the hydraulic turbine 26 is a common or connected shaft to a hydraulic pump 36. The hydraulic pump 36 is located below the level of the oil in reservoir 12b and may be placed within the reservoir as shown. It defines an inlet opening 37 for admitting oil from the reservoir 12b to the pump impeller, not shown, and to a pump discharge scroll 38. A conduit 41 containing a check valve 42 delivers low pressure oil from the discharge scroll 38 to the inlet of a suitable oil cooler 43 through which cooling water is circulated.
From the oil cooler 43, lubricating oil is supplied to a hydraulic seal of a hydrogen cooled electric generator, not shown, driven by steam turbine 1 and through a reducer 44 and conduit 45 to the lubrication system and bearing 3 of the steam turbine.

In starting the turbine 1, an auxiliary starting pump 65 driven by motor 64 is used to provide low pressure oil to the lubrication system and bearing 3. Also, an auxiliary source of liquid under pressure is required to actuate the servo motor 4 and to prime the governing system. This source may comprise a second auxiliary pump group in a dicter by 48 and consisting of a motor 51 driving a centrifugal pump 52 similar to pump 36 located below the liquid level in reservoir 12a. An inlet opening 53 is arranged to admit liquid from reservoir 12a to the pump 52. A conduit 54 supplies liquid under pressure from the pump 52 through a suitable check valve 55 to the conduit 5 where the liquid is supplied to the servomotor 4. The low pressure oil discharge from the pump 65 is led by a conduit 68 to the conduit 41 leading into the oil cooler 43. From the oil cooler 43, the low pressure oil is supplied through reducer 44 and through conduit 45 to the lubrication system of the turbine.

To start the system, the motors 51 and 64 are energized and liquid is supplied by the starting pump 52 to servo motor 4 and lubricating oil is supplied by pump 65 to bearing 3. Check valve 25 in conduit 22 prevents this priming liquid from flowing backwards through the main pump 14. Check valve 42 in conduit 41 prevents oil from flowing backwards through pump 36.

When the liquid pressure in the governing portion of the system rises to the proper value for actuating the servomotor 4, turbine 1 may be started and brought up to speed, during which the discharge pressure of the main pump 14 will increase to its normal operating value so that check valve 25 is caused to open. When the pressure in conduits 22, 32, produced by the operation of the main pump 14, rises above that produced in conduit 54 by the starting pump 52, the check valve 55 will act to prevent any leakage of oil from conduit 22 backwards through conduit 54.

Suitable control means both indicated generally as 71 may be provided for the starting motor 51 and motor 64, and so arranged that the motors are automatically deenergized when the pressure in conduits 32 and 41, respectively, rises to a value in excess of the presellected value determined by a spring 72 in each control system 71. The control systems 71 each comprise a toggle switch 73 which is well known in the art coupled to a piston 75, so that the switch 73 breaks the circuit to the motors when liquid pressure in conduits 32 and 41, respectively, exceeds the presellected value determined by the spring 72 forcing the piston 75 inward. The spring 72 biases the piston 75 so that the switch 73 is in a closed position so that motor 51 and motor 64 will be energized whenever the pressure in conduit 32 and/or 41 falls below the presellected value of a spring 72.

From the above description of the apparatus, the hydraulic system for the steam turbine 1 in effect comprises a high pressure circuit and a low pressure circuit with the shaft 34 connecting the turbine 26 of the high pressure circuit to the pump 36 of the low pressure circuit. The high pressure circuit comprises the main pump 14 in series with the parallel connected servomotor 4 of the steam turbine 1, and the hydraulic turbine 26. The low pressure circuit comprises the pump 36, the oil cooler 43 and the lubrication system of the steam turbine connected in series.

During normal operation of the steam turbine 1, liquid is delivered by the main pump 14 to the conduit 22 at a pressure suitable for operation of the servomotor 4. This pressure may be of the order of 200 pounds per square inch, which is considerably higher than is ordinarily used for lubrication purposes. The turbine lubrication system may be of the order of only 15 pounds per square inch.

An important feature of the invention is that the reduction of the liquid pressure from the value required for operation of the servomotor 4 to that required for maintaining the prime of the pump 14 is accomplished in a manner which makes use of the energy represented by this pressure drop. This is effected by causing the pressure drop to occur across the hydraulic turbine 26 which serves to drive the hydraulic pump 36. This method of conserving the energy in the system is found to make an important contribution to the overall efficiency of the prime mover by reducing the pump power needed to drive the pump 14.

This improved liquid supply system provides a liquid, which may be noninflammable, at a comparatively high pressure for operating hydraulic devices such as a servomotor 4, and also supplies oil at a much lower pressure for lubrication. This is accomplished by the high pressure system 14 coupled directly to the shaft 2 of the prime mover 4 without intermediate gearing and having the hydraulic turbine 26 arranged to positively prime the main pump 14 when the steam turbine 1 is at its operating speed.

The hydraulic turbine 26 is driven by energy derived from the drop in pressure from the high value required for the servomotor 4 to the lower value required to maintain the prime of pump 14. With this improved arrangement, a minimum quantity of liquid need be handled by the main oil pump 14, so that the power required for operating the system is kept to a minimum. By using the pressure drop inherent in the system to furnish energy for driving the hydraulic pump 36, a further important improvement in the power consumption of the system is obtained. With this invention, a very much smaller quantity of liquid need be pumped, than in other previously suggested systems. By thus reducing the volume flow in the system, the piping and conduits may be smaller than is the case in other systems. The main pump 14, the hydraulic turbine 26 and the pump 36 are designed for maximum efficiency with the main pump 14 delivering just enough pressure to operate the turbine 26 (which in turn operates pump 36) and to provide the required quantity of oil back to the main pump 14. There is no wastage of the energy available from the aforementioned pressure drop since all of the liquid from the main pump 14 passes through the hydraulic turbine 26.

The difference between the hydraulic systems shown in the accompanying drawing and the referred to parent application is that in the accompanying drawing the high pressure liquid system may utilize water or any other noninflammable liquid that is completely separate from the low pressure liquid system utilizing lubricating oil which, as in the parent application a common fluid, is used for both the governing and lubrication systems.

Although but one embodiment of a dual fluid system has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

What is claimed is:

1. In a hydraulic system including a machine requiring a primary supply of noninflammable liquid at a comparative high pressure and a secondary supply of liquid at a lower pressure, the combination of: a first pump arranged to be driven by the machine; a hydraulic turbine; a servomotor requiring a supply of noninflammable liquid at a high pressure; said first pump, said hydraulic turbine, and said servomotor forming a closed high pressure circuit with the discharge of said first pump supplied to the intake of said hydraulic turbine and said servomotor, and the discharge of said hydraulic turbine and said servomotor supplied to the intake of said first pump; a first reservoir; a second pump arranged to receive liquid from said first reservoir, the discharge of said second pump supplied to said servomotor to start the machine, and the discharge from said servomotor supplied to the intake of said first pump to prime said first pump; a first control...
means for automatically interrupting the flow of liquid from said second pump into said high pressure circuit when the pressure of the liquid delivered by said first pump exceeds the liquid pressure developed by said second pump; a second reservoir; a third pump arranged to receive oil from said second reservoir, said third pump arranged to be driven by said hydraulic turbine of said high pressure circuit; a low pressure lubrication system for the machine, said third pump and said lubrication system forming a low pressure circuit with the discharge from said third pump supplied to said lubrication system and the discharge from said lubrication system returned to said second reservoir; and means for supplying oil to said lubrication system when the machine is being started, said means comprising a fourth pump arranged to receive oil from said second reservoir, said fourth pump and said lubrication system forming a low pressure circuit with the discharge from said fourth pump supplied to said lubrication system and the discharge from said lubrication system returned to said second reservoir; and second control means for automatically interrupting the flow of low pressure oil from said fourth pump to said lubrication system when the pressure of oil delivered by said third pump exceeds the oil pressure developed by said fourth pump.

2. In a hydraulic system including a steam turbine requiring a primary supply of liquid at a comparative high pressure and a secondary supply of oil at a lower pressure, the combination of: a first pump arranged to be driven by the steam turbine; a hydraulic turbine; a first conduit connecting the output of said first pump to the input of said hydraulic turbine; a second conduit connecting the output of said hydraulic turbine to the input of said first pump whereby it is positively primed during normal operation; a servomotor requiring a supply of liquid at a high pressure; a third conduit connecting the output of said first pump to the input of said servomotor; a fourth conduit connecting the output of said servomotor to the input of said first pump; a first liquid reservoir; means for starting the steam turbine and priming said first pump including a second pump arranged to receive liquid from said first reservoir and to supply high pressure liquid through a fifth conduit to the inlet of said servomotor to actuate said servomotor to cause steam to be admitted to the steam turbine to start the steam turbine and the output of said servomotor supplied to said first pump to prime said first pump; first control means for automatically deenergizing said second pump when the pressure of the liquid delivered by said first pump exceeds the high pressure liquid delivered by said second pump; a second oil reservoir; a third pump arranged to receive oil from said second reservoir, said third pump arranged to be driven by said hydraulic turbine; a lubrication system for the steam turbine requiring a supply of oil at a low pressure; a sixth conduit connecting the output of said third pump to the input of said lubrication system; a seventh conduit connecting the output of said lubrication system to said reservoir; means for supplying low pressure oil to said lubrication system when the steam turbine is being started including a fourth pump arranged to receive oil from said second reservoir and to supply low pressure oil through an eighth conduit to said lubrication system; second control means for automatically deenergizing said fourth pump when the pressure of the oil delivered by said third pump exceeds the low pressure oil delivered by said fourth pump, and check valve means in said third, said fifth, said sixth and said eighth conduits for preventing reverse flow through said first pump, said second pump, said third pump and said fourth pump, respectively.

No references cited.