

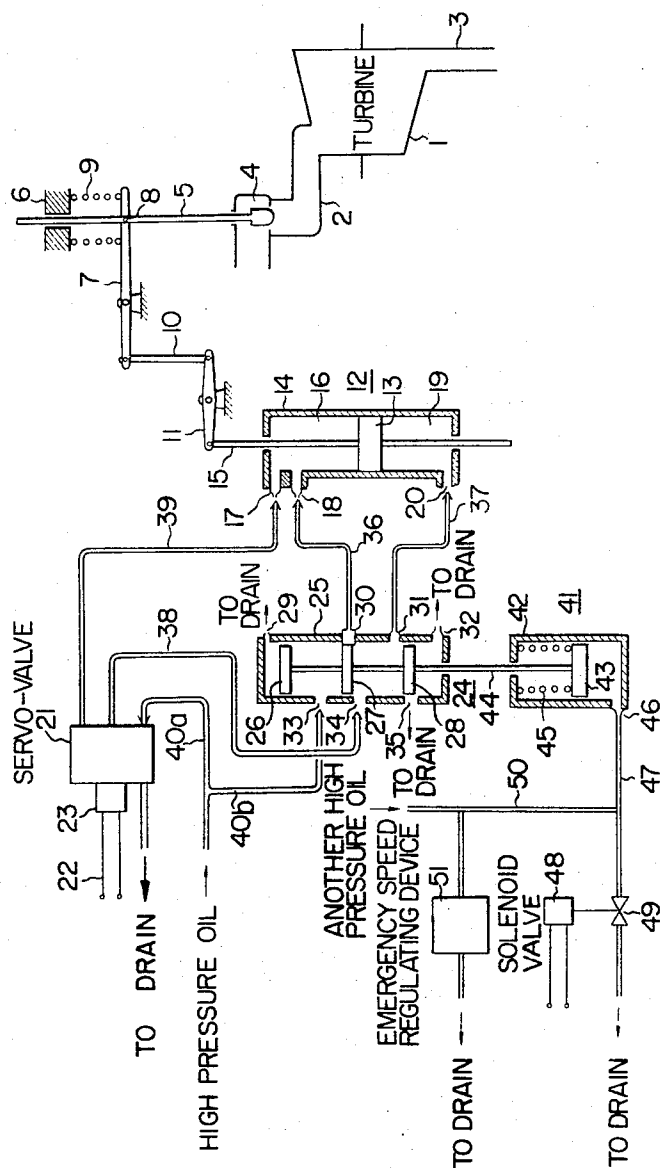
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CONTROL SYSTEM FOR STEAM TURBINES

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1

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CONTROL SYSTEM FOR STEAM TURBINES
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10 Claims

ABSTRACT OF THE DISCLOSURE

A steam turbine control system including a valve means for regulating the flowrate of steam supplied to the turbine in response to an electric signal is featured by the combination of a servo-motor for driving the valve means upon reception of comparatively high pressure oil as its operative fluid, a servo-valve for distributing the operative fluid to the servo-motor in accordance with the above mentioned electric control signal, a by-pass valve inserted in the fluid path from the servo-valve to the servo-motor for the purpose of operating the valve means in the closing direction in response to a trip signal which supersedes the electric control signal at an emergency, regardless of the distribution of the operative fluid from the servo-valve, and a dump-valve driven by a comparatively low pressure operative fluid for driving the by-pass valve in response to the above mentioned trip signal.

BACKGROUND OF THE INVENTION

This invention relates to improvements in steam turbine control systems, and more particularly to a type thereof wherein a safety device for emergency shut-off of the main steam valve is provided in addition to the main steam control devices.

It is widely known that an electro-hydraulic control system for a steam turbine requires not only a servo-valve operable under the control of an electric control signal and a servo-motor operated by a high pressure fluid distributed by the servo-valve but also a protective control device capable of closing the main steam stop valve upon reception of a trip signal in the form of either an electric or electro-hydraulic signal.

To assure a quick response in the ordinary servo-valve and servo-motor operation, a fluid at a high pressure ranging from 100 kg./cm.² to 200 kg./cm.² is employed and may consist of a flame retardant synthetic oil such as a phosphoric ester. On the other hand, a pressurized fluid employed in the trip control system is not necessarily at such a high pressure, and an ordinary turbine oil may be economically used for this purpose.

However, because these two kinds of oils are of different chemical nature, these oils cannot be mixed in the control system.

SUMMARY OF THE INVENTION

Therefore, the principal object of the invention is to provide a steam turbine control system including a separate safety device for closing the main steam stop valve in an emergency, in which two kinds of the operative fluid employed therein are not mixed.

Another object of the invention is to provide a steam turbine control system including a safety device which by-passes the servo-valve in an emergency.

Still another object of the invention is to provide a steam turbine control system including a safety device

2

which is simple in construction and economical in its manufacture.

These and other objects of the invention can be achieved by an improved construction of the steam turbine control system including a main steam stop valve for controlling the flowrate of steam supplied to the turbine in response to an electric signal, said system comprising, in combination, a servo-motor for driving the stop valve upon reception of a comparatively high pressure oil as its operative fluid, a servo-valve for distributing the operative fluid into the servo-motor in accordance with the above mentioned electric control signal, a by-pass valve inserted in the fluid path from the servo-valve to the servo-motor for operating the stop valve in the closing direction in response to a trip signal which supersedes the electric control signal in an emergency regardless of the distribution of the operative fluid from the servo-valve, and a dump-valve driving the by-pass valve in response to the above-mentioned trip signal or to the operation of an emergency speed regulating device for the turbine.

The nature, principle, and utility of the invention will be more readily apparent from the following detailed description with respect to a preferred embodiment thereof when read in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF DRAWING

The single figure of the accompanying drawing is a schematic hydraulic-system diagram showing an example of a safety device constituting an embodiment of the present invention.

DETAILED DESCRIPTION

As is indicated in the attached drawing, a steam turbine 1 having a steam inlet pipe 2 and a steam outlet (or exhaust) pipe 3 is connected to a steam generating plant (not shown) through a main steam pipe line including a stop valve 4. The valve body of the stop valve 4 is connected to an operating rod 5, the upper part of which is slidably received in a supporting structure 6. An intermediate point of the operating rod 5 is pivotally connected to an end of a lever 7 by a pivot pin 8, and between the supporting structure 6 and the lever 7 a coiled spring 9, for instance, urging the valve 4 toward its closed position is provided around the operating rod 5. An intermediate point of the lever 7 is pivotally supported on a fixed structure, and the other end of the lever 7 is also pivotally connected to the upper end of a rod 10, the lower end of which is further pivotally joined to one end of a generally horizontal lever 11. The middle point of the lever 11 is also pivotally supported by a fixed structure through a pivot pin, and the other end thereof is pivotally coupled to the upper end of a piston rod 15 for a piston 13 which is disposed within a cylinder 14 of a servo-motor 12 employed for open-or-closing the stop valve 4.

At the upper portion of the cylinder 14, two oil ports 17, 18 communicating with the upper chamber 16 of the cylinder 14 are provided, and at the lower portion of the same cylinder 14, an oil port 20 communicating with the lower chamber 19 thereof is provided. The servo-motor 12 is driven at its normal operating condition by a highly pressurized fluid distributed from a servo-valve 21 which is operated through a solenoid 23 having terminals 22 connected with an electric control system.

A pilot valve (or a by-pass valve) 24 provided for blocking or by-passing the operation of the servo-motor 12 depending on an electric control signal which is imparted to the terminals 22 at the time a tripping signal

3

is transmitted, has a cylinder 25 and three pistons 26, 27, and 28 coaxially fixed to a common rod 44 with a mutually spaced part relationship and adapted to operate within the cylinder 25.

The cylinder 25 is provided with oil ports 29, 30, 31, 32, 33, 34, 35. At the time of normal operation, the pistons 27, 28 block the ports 30, 35, respectively, and the ports 31 and 34 are communicated with each other. On the other hand, at the time of the tripping operation, the piston 27 blocks the port 34 and thereby the ports 30, 33, and the ports 31, 35 are communicated respectively.

The oil ports 30, 31 on the pilot valve 24 are respectively connected to the ports 18, 20 of the servo-motor 12 through conduit tubes 36, 37. For the purpose of supplying the highly pressurized oil to the servo-valve 21 and the pilot valve 24, a bifurcated pipe line 40a and 40b is provided to be connected with a high pressure oil source (not shown). The above described oil port 34 is communicated with a chamber (not shown) in the servo-valve 21 through a pipe line 38. The other chamber (not shown) in the servo-valve 21 is connected with the oil port 17 of the servo-motor 12 through a pipe line 39. The servo-valve 21 distributes the highly pressurized oil supplied from the pipe line 40a to the pipe line 38 when a signal received at the terminals 22 is to operate the stop valve 4 in the opening direction, and to the pipe line 39 when the signal is to operate the valve 4 in the closing direction.

For operating the pilot valve 24, a dump-valve 41 is disposed below the pilot valve 24. The pistons 26, 27, and 28 in the pilot valve 24 are coupled to a piston 43 within a cylinder 42 of the dump-valve 41 through a rod 44. Inside of the cylinder 42, there is provided a coil spring 45 urging the piston 43 downwardly. At the lower end of the cylinder 42, an oil port 46 is provided, and the oil port 46 is connected to a pipe line 47.

At the other end of the pipe line 47, a normally closed valve 49 which is open-or-closed by an electro-magnetic switch 48 is provided so that the switch 48 is operated by a trip signal. The pipe line 47 is further connected to a pipe line 50 communicating with another pressurized oil source, and the pipe line 50 is provided with an emergency regulating device 51 which discharges the pressurized oil to a drain in response to an abnormal over-speed of the turbine. The oil employed in this part of the system can be any ordinary turbine oil.

The operation of the safety device according to the present invention will now be described.

At the time of the normal operation, when a signal for opening the stop valve 4 is received at the terminals 22 of the solenoid 23, the servo-valve 21 operated by the solenoid 23 distributes the highly pressurized oil of approximately from 100 kg./cm.² supplied from the pipe line 40a to the pipe line 38. The pressurized oil through the pipe line 38 is fed to the oil port 34 of the pilot valve 24, then through the chamber between the pistons 27, 28 to the oil port 31, and then to the pipe line 37. The oil is thereafter passed from the port 20 into the lower chamber of the servo-motor 12. As a result, the piston 13 is pushed upward together with the piston rod 15, and the lever 11 is rotated clockwise. The rotation of the lever 11 in the clockwise direction is transmitted through the rod 10 to the lever 7 which is thereby rotated in the counterclockwise direction. The main steam stopping valve 4 is opened through the upward movement of the rod 5 against the resistive force of the spring 9, and the steam is supplied through the inlet pipe line 2 to the turbine 1.

On the other hand, when a signal for closing the main steam stop valve 4 is sent to the servo-valve 21, the highly pressurized fluid furnished through the pipe line 40a enters the oil port 17 of the servo-motor 12 through the pipe line 39 and is passed into the upper chamber 16 of the servo-motor 12, thus pushing down the piston 13.

4

With the downward movement of the piston 13 and the piston rod 15, the lever 11 is rotated in the counterclockwise direction, rotating the lever 7 in the clockwise direction through the rod 10 and pushing down the rod 5 of the stop valve 4, whereby the valve 4 is closed.

However, if any trouble occurs in the electric control system or in the servo-valve itself, or if the steam turbine over-speeds to a dangerous point, it is required that the main steam stop valve 4 be instantaneously closed for protection of the turbine. In such a case, an electric signal is sent to the electro-magnetic switching device 48, which thereupon opens the valve 49 for discharging the pressurized fluid supplied from the pipe line 50 to the pipe line 47 to the drain. If the turbine speed increases to an abnormal speed, the emergency speed regulating device 51 will operate, and the pressurized fluid supplied in the pipe lines 50, 47 will be exhausted through another drain tube. When the pressurized fluid in the pipe lines 50, 47 is drained, the oil pressure acting on the lower chamber of the piston 43 in the dump-valve 41 is decreased, and the piston 43 is pushed down by the spring 45. The downward movement of the piston 43 pushes down the pistons 26, 27, and 28 inside the pilot-valve 24 through the piston rod 44, so that the oil ports 30 and 34 are opened and closed, respectively, by the piston 27, and the oil port 35 is opened by the piston 28. Accordingly, the high pressure fluid in the pipe line 40b is passed directly through the oil ports 33, 30 between the pistons 26, 27, pipe line 36, and the oil port 18 of the servo-motor 12, successively, thus by-passing the servo-valve 21 and supplying the pressurized fluid into the upper chamber 16 in the servo-motor 12. The piston 13 is thereby pushed down, lowering the piston rod 15 downward. This in turn rotates the lever 11 counterclockwise, pushing the rod 10 upward and rotating the lever 7 clockwise. The clockwise rotation of the lever 7 pushes down the rod 5 of the stop valve 4, thus closing abruptly the main steam stop valve 4 and interrupting the steam supply thereby to protect the turbine.

We claim:

1. A steam turbine control system including valve means for regulating the flow rate of steam supplied to a turbine in response to an electric signal, said system comprising a fluid operated servo-motor for driving said valve means, a comparatively high pressure supply of fluid, servo-valve means for distributing the comparatively high pressure fluid to said servo-motor in accordance with said electric control signal to operate said servo-motor to selectively open and close said valve means, a by-pass valve connected between said servo-valve and said servo-motor for controlling said distribution of fluid to said servo-motor to drive said valve means in the closing direction in response to a trip signal, a comparatively low pressure supply of fluid, and fluid operated dump-valve means for operation with said comparatively low pressure fluid to drive the by-pass valve in response to the above mentioned trip signal.

2. A steam turbine control system as defined in claim 1 wherein said dump-valve means is operable also in response to the operation of an emergency speed regulating device.

3. A steam turbine control system as defined in claim 1, wherein said system includes fluid conduit means for maintaining said comparatively low pressure fluid completely separated from said comparatively higher pressure fluid.

4. A steam turbine control system as defined in claim 1 wherein said comparatively higher pressure fluid consists of a flame retardant synthetic oil such as a phosphoric ester, and the comparatively low pressure fluid consists of a turbine oil.

5. A steam turbine control system as defined in claim 1 wherein said by-pass valve has three pistons connected to operate in unison and operated by said dump-valve, whereby, in tripping operation, the higher pressure opera-

5

tive fluid is passed into said servo-motor, by-passing said servo-valve to close said valve means.

6. A steam turbine control system as defined in claim 1, wherein said servo-motor has a piston and first and second cylinder chambers respectively on opposite sides of said piston, and conduit means between said servo-valve means and said servo-motor to deliver said high pressure fluid alternately to said first and second chambers of the servo-motor, whereby, in the normal operating state, the operation of said valve means is controlled by the servo-valve means.

7. A steam turbine control system as defined in claim 1 wherein said high pressure fluid is supplied through a bifurcated pipe line, one branch of which is connected to said servo-valve means and the other branch of which is connected to an inlet port of said by-pass valve.

8. A steam turbine control system as defined in claim 1 further comprising first and second conduit means, wherein said distribution of the high pressure fluid from said servo-valve means to said servo-motor in accordance with said electric control signal is carried out through said conduit means, and wherein said servo-motor has opposed first and second cylinder chambers and a piston disposed for movement within said cylinders, said first conduit means is connected between a first port of said servo-valve means and said first cylinder chamber of said servo-motor, and said second conduit means is connected through said by-pass valve from a second port of said servo-valve means to said second cylinder chamber of the servo-motor, whereby the opening operation of said valve means is allowed only when no trip signal is applied to said dump-valve.

9. In a steam turbine control system including steam valve means for regulating the flow rate of steam supplied to a turbine in response to an electrical signal, an improvement wherein said system comprises a fluid operated servo-motor connected to open and close said steam valve means, said servo-motor having first and second cylinder chambers, and a piston disposed for movement within said cylinder chambers and coupled to said valve means for controlling said flow rate, servo-valve means

6

adapted for actuation by said electrical signal, by-pass valve means, a high pressure supply of fluid connected to said servo-valve means and said by-pass valve means, said servo-valve means having a first port connected to said first cylinder chamber and having a second port connected to said by-pass valve means, said first and second cylinder chambers also having connections to said by-pass valve means, means for maintaining said by-pass valve means in position to allow fluid flow between said second port and second chamber so that said steam valve means is controlled by operation of said servo-valve means, and means for driving said by-pass valve means to by-pass said servo-valve means and operate said servo-motor to close said steam valve means in response to a trip signal.

10. A turbine control system as set forth in claim 9, in which said by-pass valve means comprises a cylinder chamber having a plurality of pistons, and said means for driving said by-pass valve means includes a low pressure fluid operated dump-valve having movable means connected to said plurality of pistons, a low pressure supply of fluid coupled to operate said dump-valve, and means for controlling said dump-valve to move said plurality of pistons in response to said trip signal.

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