March 23, 1954 H. HILLIER 2,672,820

CENTRIFUGAL PUMP

Filed April 22, 1952 3 Sheets-Sheet 1

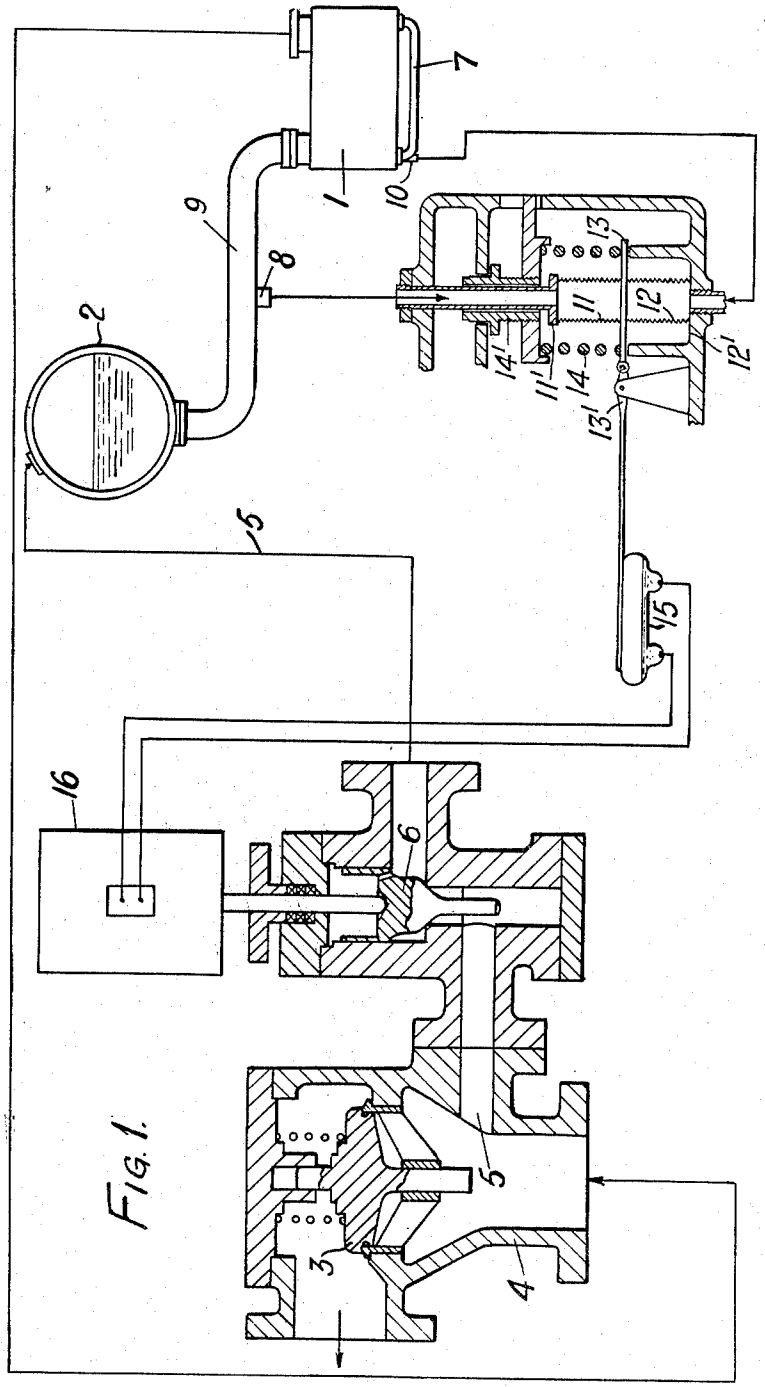


FIG. 1.

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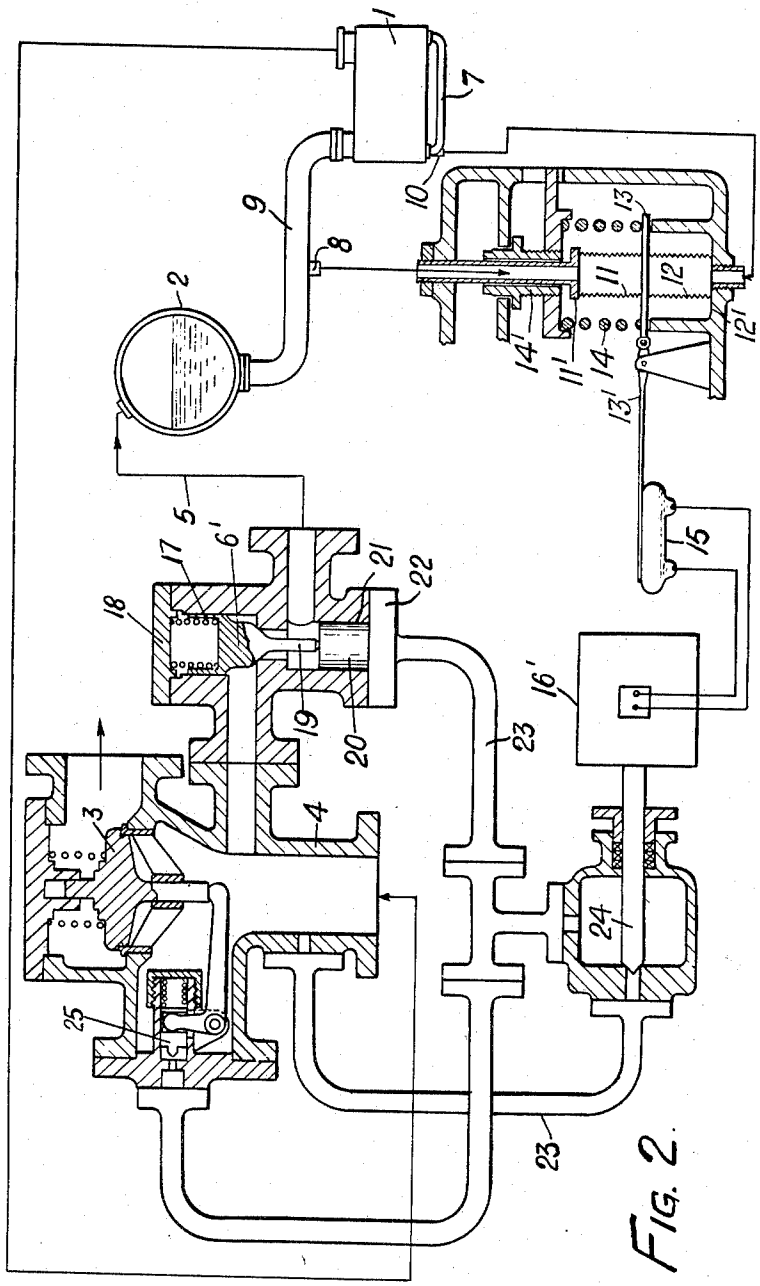


FIG. 2.

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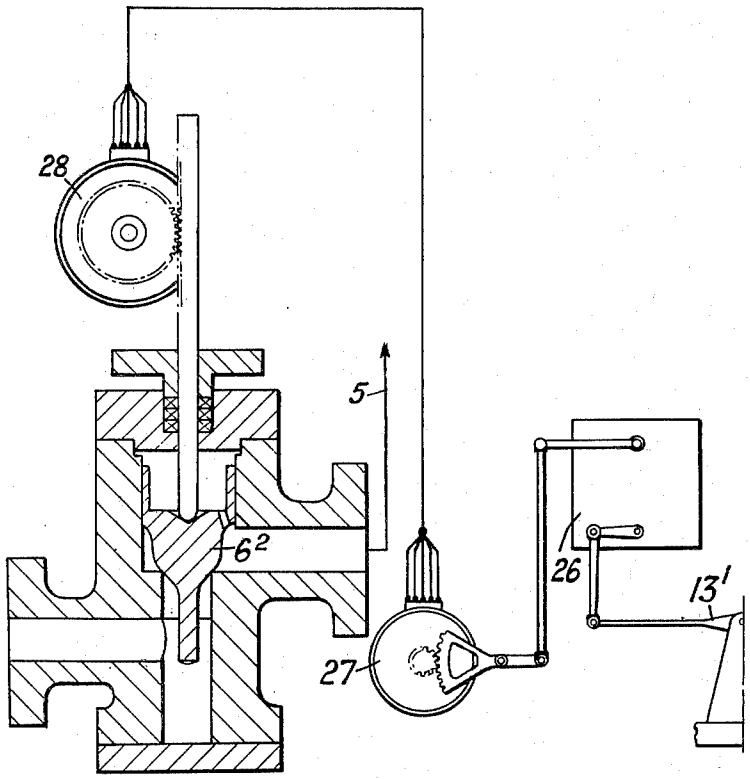


FIG. 3.

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UNITED STATES PATENT OFFICE

2,672,820

CENTRIFUGAL PUMP

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Claims priority, application Great Britain April 27, 1951

4 Claims. (Cl. 103—41)

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This invention is directed to the prevention of damage to liquid pumps of the centrifugal type when operating against a closed discharge valve or with a very small liquid flow from the discharge side of the pump.

When a centrifugal pump is in operation, a proportion of the energy transmitted to the pump by the driving unit is absorbed in friction, shocks, eddies and churning within the pump. The energy so dissipated is transformed into heat which increases the temperature of the liquid flowing through the pump. With a considerable flow of liquid through the pump, the resultant temperature rise is comparatively small and does not involve any serious consequences, but, when the pump is operating against a closed discharge valve or with a very small flow of liquid through the pump, the temperature rise may be considerable and may be such that, in a few minutes, the temperature of the liquid within the pump is raised to the boiling point, and a portion of the liquid is evaporated. Such evaporation may prevent the flow of water into the suction of the pump, thereby preventing the pump from discharging liquid, with the result that seizure may occur between the rotating and the stationary parts owing to the lack of an adequate supply of liquid for cooling and lubricating purposes.

The operating conditions of centrifugal pump installations are often such that a certain minimum flow through the pump is necessary in order to prevent such dangerous conditions from arising, and provision is usually made to ensure that, when there is a danger of the flow through the pump falling below the minimum required to ensure safe operation, an emergency outlet from the discharge of the pump is opened, either by hand or automatically, to allow the pump to discharge a predetermined minimum quantity of liquid back to the source of liquid supply, such predetermined quantity being fixed to prevent a dangerous rise in temperature through the pump under any condition of operation.

The quantity of water passing through such an emergency outlet is usually known as the bypass discharge.

For centrifugal pump installations the operating conditions may be such that a hand-operated bypass meets all requirements, but, in many installations, such as those including centrifugal pumps used for boiler feed purposes, it is necessary to operate two or more centrifugal pumps discharging in parallel, and such pumps are so devised as to share proportionally the total quantity of water discharged. With extremely small

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liquid flows, it is barely practicable to ensure that each pump will discharge its proper share of the total load, and operating conditions may arise in which the flow is completely stopped. Such occasions arise in a haphazardous fashion, and it is not possible to anticipate them by manual operation of the bypass discharge, so that it is necessary that such bypass should be opened automatically whenever the flow falls below the necessary minimum.

Centrifugal pumps are usually provided on the discharge side with a non-return valve which closes in the event of there being any tendency for liquid to flow back from the discharge line through the pump. It is known to use the closing motion of a non-return valve in the discharge line to open a bypass discharge, either directly or through a relay, a typical example of such an arrangement being disclosed in the prior specification No. 2,397,664.

The closing motion of the non-return valve is usually assisted by means of a spring, and, in some circumstances, the force available is limited to that which can be applied by the spring. In large installations, it is of extreme importance that boiler feed pumps should be maintained in operation and any risk of damage avoided, and it is desirable, therefore, that the operation of the bypass discharge should be safeguarded as far as possible.

The invention provides an improved apparatus for controlling the flow of bypass liquid from a centrifugal pump in that the opening of the bypass valve is effected in response to a predetermined rise in temperature of the feed water passing through the pump, such action being supplementary to or in substitution for the hydraulic action of apparatus such as described in specification No. 2,397,664.

With a considerable flow of liquid through the pump, the temperature rise owing to causes already stated is comparatively small, but the temperature rise increases as the flow through the pump is reduced. The invention contemplates the use of this increase in temperature rise at a given low flow through the pump for the purpose of actuating the bypass discharge device whereby the flow through the pump is prevented from falling below the minimum quantity of water which can be passed through the bypass discharge device.

With this purpose in view there are provided two thermostats, one in the pump suction system where it will be exposed to the temperature of the water entering the pump and the

other in the pump discharge system where it will be exposed to the temperature of the water at the discharge of the pump. For convenience, the second thermostat may be arranged in the hydraulic balance discharge line wherein there is a continuous flow of water at a temperature slightly higher than the temperature of water at the discharge of the pump. Each of the two thermostats may be included in a closed system including a Sylphon bellows or the like, the system being filled with an expansive liquid or gas whereby the volume and/or the pressure in the system rises with increase in temperature, the increase in volume being accommodated as desired by the expansion of the bellows.

The two bellows operating in conjunction with the two thermostats may be interconnected by a common diaphragm or connecting plate, the said diaphragm being subjected to the pressures on each side which are generated by the liquid within the thermostatic systems. The opposite ends of the two bellows may be rigidly or elastically maintained in position relatively to one another, so that, whenever the pressure in one bellows increases above the pressure in the other bellows, the common diaphragm will move in the direction of the lower pressure. The bellows at high pressure may be rigidly fixed at one end while the bellows at the lower pressure is supported by an elastic member such as a spring, set to balance a predetermined difference in pressure between the two bellows, the common diaphragm being free to move as the pressure in the high pressure bellows increases.

The movement of the common diaphragm may be arranged to operate a power relay of the pneumatic, hydraulic, or electric type, and, for example, in the last mentioned case it may control a flow of electric current to an electromagnet or solenoid thrustor or motor operated device, whereby a pilot valve is opened to permit the flow of operating water to a piston which causes the bypass valve to open and permit the discharge of bypass water to the suction system of the pump. To ensure that there is no leakage from the pump during normal operating conditions, the pilot valve is preferably of the seated type; the bypass valve is also preferably of the seated type.

A spring may be provided to exercise a force holding the bypass valve on its seat and the spring load plus the discharge pressure of the pump acting on the top of the valve maintains the valve closed and thereby ensures absence of leakage through the bypass valve under normal operating conditions of the pump.

On the underside of the bypass valve, there may be provided a piston having an area considerably in excess of the bypass valve area. The underside of the piston is in communication with the pilot valve which is operated electrically under the control of the common bellows diaphragm. When the pilot valve opens, the discharge pressure of the pump is applied to the remote side of the piston, causing the piston to move upwards and lift the bypass valve from its seat, thereby permitting the bypass discharge liquid to pass through the bypass valve to the source of liquid supply. When the pilot valve is closed, the water in the chamber under the piston leaks through the clearance between the piston and the chamber to the source of liquid supply, so that the piston is balanced and the spring load plus the pump discharge pressure acting on the top of the bypass valve causes the bypass valve to return to the closed position.

The electrically operated pilot valve may be used in parallel with a mechanically operated pilot valve such as is disclosed in the prior specification No. 2,397,664.

The action of the common bellows diaphragm may be used to actuate a switch whereby electrical power is used to operate a motor, electromagnet or thrustor to open directly to bypass discharge valve, or the arrangement may be such that the motor, electromagnet or trustor maintains the bypass valve in the closed position, and the movement of the common diaphragm actuates the switch, whereby the electric power is cut off and the discharge pressure of the pump acting alone or in conjunction with a spring causes the bypass discharge valve to open and allow bypass water to be discharged from the delivery of the pump to the suction system of the pump.

The movement of the common bellows diaphragm may be arranged to operate the electric supply for a given temperature rise through the pump, and there may be provided adjustment means whereby the movement of the said diaphragm can be caused to take place with increased or decreased temperature rise as may be found desirable when the pump is in operation.

It may be provided that the movement of the common diaphragm will move the switch across a variable resistance, whereby the opening of the bypass valve can be varied between zero and full open so as to maintain a substantially constant predetermined difference in temperature across the pump, whereby the quantity of bypass water is increased as the flow through the pump is reduced and vice versa. For this purpose, the motor, electro-magnet or thrustor may be arranged to vary in its movement or stroke in accordance with the position of the switch actuated by the common diaphragm.

The bellows-operated switch may be arranged to actuate a master electrical device, the position of which controls a slave electrical device, so that the position of the slave device is determined by the position of the master device, while the slave device controls the opening of the bypass valve at any desired position between closed and full open.

In order that my invention may be clearly understood, there will now be described in further detail practical embodiments of the invention illustrated in the accompanying drawings in which Fig. 1 illustrates diagrammatically an arrangement of automatic bypass with thermal operation, and Fig. 2 illustrates diagrammatically the arrangement of an automatic bypass with thermal and mechanical operation. Fig. 3 is a fragmentary view showing a modification incorporating a proportionate transmitter and receiver between the thermostats and the bypass valve.

Referring to Fig. 1, a centrifugal pump **1** is arranged to draw water from a supply tank **2** and discharge past a non-return valve **3** to a boiler (not shown). On the underside of the non-return valve **3** there is provided a branch **4** from which a bypass discharge line **5** is led back to the supply tank **2**, and a control valve **6** is arranged in the bypass discharge line to control the flow of bypass water. The pump **1** is provided with a hydraulic balancing device **7**.

A thermostat **8** is arranged in the suction line

9 to the pump 1 so that it is subjected to the temperature of the water entering the pump, while another thermostat 10 is arranged in the balance leakage discharge line 7 so that it is subjected to the temperature of the discharge water in that line. The thermostat 8 is connected to a Sylphon bellows 11 by a closed system which is filled with a liquid or gas responsive to the temperature of the thermostat 8, while the thermostat 10 is connected by a closed system to another Sylphon bellows 12 filled with a gas or liquid responsive to the temperature of the discharge thermostat 10.

The bellows 11 and 12 are coupled together at a common sensitive member 13 in the form of a diaphragm or plate. One end of the bellows 12 is held in position at 12', while the other end acts on the member 13. One end of the bellows 11 is held firmly at 11', while the other end acts on the member 13. A spring 14 acts on the member 13 in opposition to the bellows 12, the stress of the spring 14 being variable by adjustment of a nut member 14'. The movement of the member 13 may be amplified, as shown, by a simple lever device 13'. The position of the member 13 is determined by the difference between the suction temperature and the discharge temperature of the water passing through the pump 1 and by the loading of the spring 14 which can be pre-set to balance any desired temperature difference. The member 13 will move to one side or the other of its equilibrium position, as the temperature difference rises or falls. The movement of the member 13 caused by a rise in the temperature difference is arranged to move a mercury switch 15 controlling the supply of electric current to an electric thrustor 16 which, in normal operation, maintains the bypass valve 6 in the closed position, but, on the temperature difference rising to a predetermined figure, the movement opens the switch 15, thereby interrupting the current to the thrustor 16, so that the pump pressure opens the bypass valve 6 and bypass water is discharged to the supply tank 2.

The switch 15 is so arranged that the member 13 must move through a substantial reverse stroke before it moves the switch 15 into the closed position and so causes the thrustor 16 to close the bypass valve 6. As will be understood, by adjustment of the nut member 14' the load of the spring 14 may be pre-set to determine the temperature difference at which the switch 15 will be operated.

Thermometers may be provided to facilitate the setting of the temperature difference at which the switch is operated.

Referring to Fig. 2, the thermostatic control may be used, as shown, to control a hydraulic pilot valve and bypass valve of the type described in the prior specification No. 2,397,664. The bypass valve 6' is of the seated type with a spring 17 between the valve 6' and a cover 18 to assist in closing the valve 6'. The discharge pressure of the pump 1 acts on top of the valve 6' in conjunction with the spring 17. The bypass valve 6' is provided with a spindle extension 19 which passes through the bypass valve seat and makes contact with a piston 20 which moves freely in a chamber 21 provided on the outlet side of the bypass valve seat. The chamber 21 has a cover 22 which is connected by a pipe 23 to the discharge of the pump and the flow through this pipe is controlled by a pilot valve 24, the opening and closing of which is effected through a relay mechanism by the movements of a common member 13 of the thermostatic systems, as in the Fig. 1 construction.

The area of the piston 20 is considerably greater than the area of the valve 6' so that, when the valve 6' is opened, water at the discharge pressure of the pump applied to the underside of the piston 20 overcomes the force of the water applied on top of the valve 6' plus the spring, so that the valve 6' moves into the open position and allows the pump to discharge past the valve 6' to the supply tank 2. When the valve 6' closes, the water in the piston chamber 21 leaks through the clearance between the piston 20 and the chamber walls 21 to the bypass outlet until the pressures on the two sides of the piston are equalised. The pump discharge pressure plus the spring then causes the valve 6' to close and cut off all flow through the bypass connection.

Owing to the fact that it controls only a small quantity of water to actuate the bypass valve opening piston 20, the valve 24 may be very small so that the force necessary to operate the valve 24 is reduced to a minimum. The action of the solenoid 16' is effected under the control of a mercury switch 15 which is opened and closed by the movements of the member 13 of the thermostatic systems, so that the valve 24, and, therefore, the valve 6', are opened when a predetermined difference in temperature between the suction and discharge temperature is reached and closed when another predetermined lower difference in temperature is reached, so that hunting in the opening of the bypass valve is avoided.

As shown, there is provided an additional pilot valve 25 operated mechanically by the closing motion of the pump discharge non-return valve 3 as described in the prior specification No. 2,397,664, so that the bypass may be operated by either or both of these systems.

In the modification shown in Fig. 3 the movement of the thermostat lever 13' is transmitted through a torque amplifier 26 to a transmitter 27 and receiver 28, which latter is operatively connected to the bypass valve 6^2, whereby the valve 6^2 is operated proportionately to the resultant movement of the thermostatic devices.

It will be understood that the constructional details and applications may be varied without departure from the invention.

What is claimed is:

1. Means for controlling the discharge of bypass liquid from a centrifugal pump, including a discharge line leading from the centrifugal pump, a bypass line connected into the discharge line, a bypass valve in the bypass line, a sensitive member, two thermostatic devices arranged to act on and move said sensitive member, said thermostatic devices being responsive respectively to changes in the suction and the discharge temperatures of the liquid flowing through the pump, and power means responsive to the movement of said sensitive member for opening or closing said bypass valve in dependence on the resultant movement of said sensitive member by said thermostatic devices.

2. Means as claimed in claim 1, including an electrically operable means for opening and closing the bypass valve, and an electric switch actuatable by said sensitive member for in turn controlling the supply of current to said electrically operable means.

3. Means as claimed in claim 1, including a pilot valve actuatable by the sensitive member

and arranged to bring about the opening or closing movement of the bypass valve.

4. Means as claimed in claim 1, including a non-return valve in the discharge line leading from the centrifugal pump downstream of the bypass line leading from the discharge line, the closing and opening motion of the non-return valve acting to bring about the opening and closing respectively of the bypass valve.

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