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HEAT ACTUATED FLOW CONTROL APPARATUS

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Fig. 3

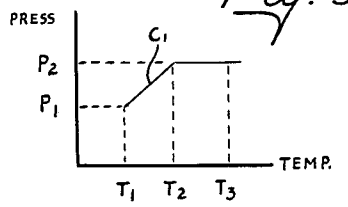


Fig. 1

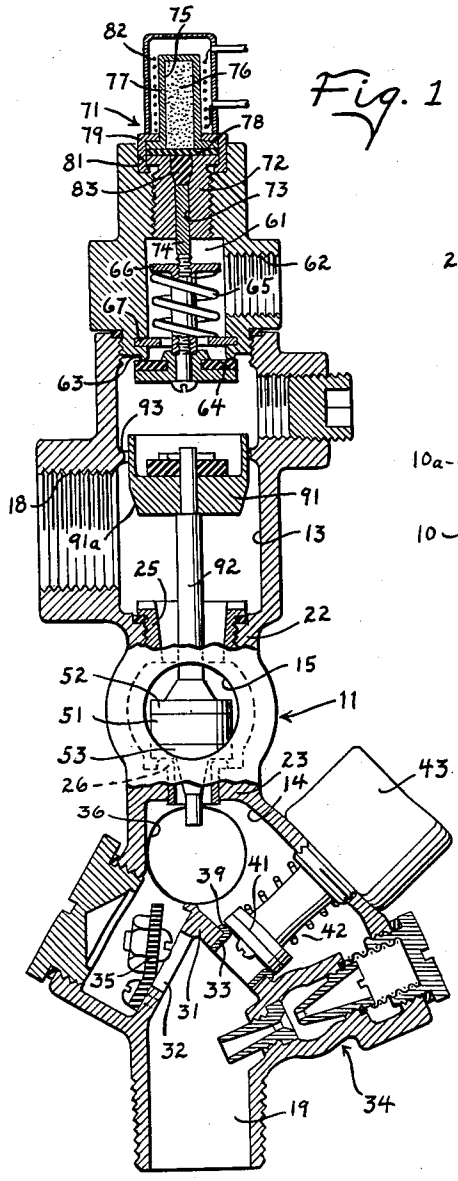
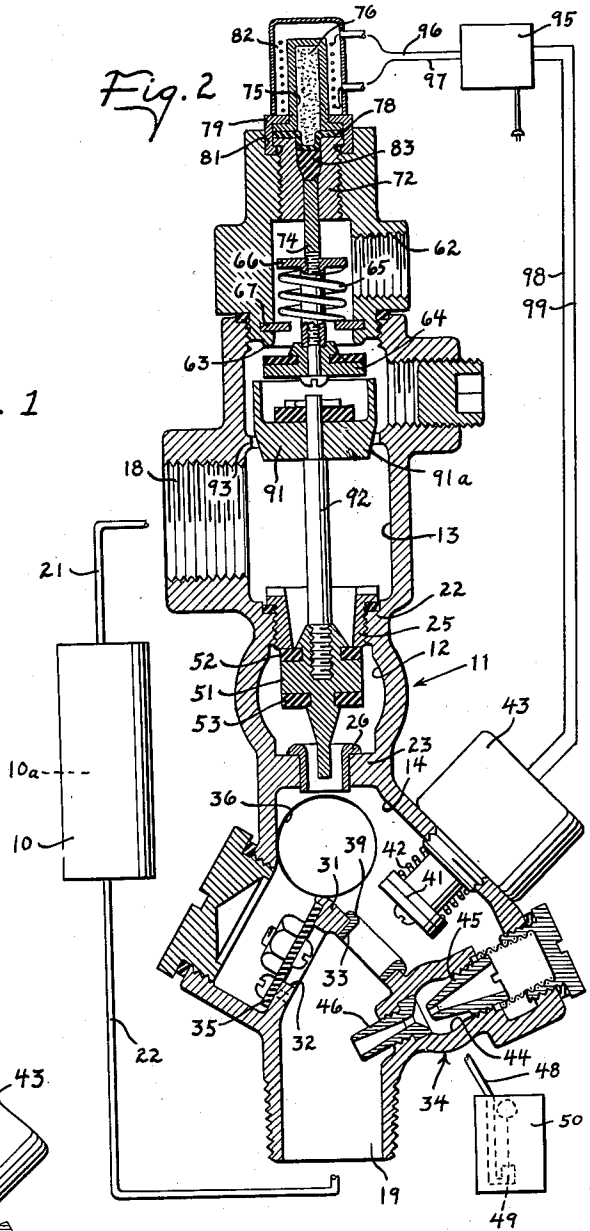


Fig. 2



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Atty's

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HEAT ACTUATED FLOW CONTROL APPARATUS

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This invention relates to novel and useful improvements in ontrol systems for a water treatment apparatus.

An important object of this invention is to provide an improved control system for reversibly controlling the flows of fluid through a water treatment apparatus, which control system is simple in construction, avoids water hammer, and is reliable and quiet in operation.

Another object of this invention is to provide an improved flow control system for a water treatment apparatus in which the rate of flow of liquid through the treatment tank during backwash can be correlated with the temperature of the liquid flowing through the treatment tank to increase the backwash rate when the temperature increases to provide proper expansion of the bed of exchange material in the treatment tank.

A more particular object of this invention is to provide a control system for reversibly controlling the flows of fluid through a water treatment apparatus of the type including a main flow reversing valve and a drain valve which is operative when open to actuate the main valve to backwash fluid through the treatment apparatus and out through the drain valve and wherein a heat motor is provided for operating the drain valve and arranged to be cooled by the liquid flowing through the drain valve to prevent overheating of the heat motor.

These, together with various ancillary objects and advantages of this invention will be more readily appreciated as the same becomes bettter understood by reference to the following detailed description when taken in connection with the accompanying drawings wherein:

FIGURE 1 is a sectional view through the control apparatus for reversibly controlling the flows of fluid through a treatment tank and showing the same in its service position,

FIG. 2 is a sectional view through the control apparatus and showing the same in its backwash position, and

FIGURE 3 illustrates the relation between the travel of the heat motor actuator and the temperature of the expansible material therein.

The control system includes a main flow control valve arranged to reversibly control the flows of fluid through a treatment tank 10 having a bed of exchange material 10*a* therein. The main valve comprises a casing 11 defining an inlet chamber 12 and spaced outlet chambers 13 and 14. An inlet passage 15 communicates with the inlet chamber and is adapted for connection to a raw water supply line (not shown) and top and bottom outlet passages 18 and 19 respectively communicate with the upper and lower chambers and are connected through conduits 21 and 22 to the treatment tank 10.

The casing 11 has partitions 22 and 23 which separate the inlet chamber 12 from the top and bottom outlet chambers 13 and 14, which partitions have ports therein and upper and lower valve seats 25 and 26 disposed around the ports. In the embodiment illustrated, a partition 31 separates the lower chamber 14 from the lower flow passage 19 and a by-pass port 32, a rapid rinse port 33 and an ejector 34 are formed in the partition. A check valve 35 is mounted on the partition 31 and arranged to close the by-pass port 32 to prevent flow from the lower chamber 14 to the lower flow passage, and to open for reverse flow therethrough to permit treated water from the bottom of the tank to pass to the service outlet passage 36 which communicates with the lower

flow chamber 14. The rapid rinse port 33 has a seat 39 disposed therearound and a valve member 41 is cooperable with the seat and is normally urged by a spring 42 to a position blocking flow through the rapid rinse port. Means, such as the solenoid 43, are provided for selectively opening the rapid rinse valve 41. The ejector 34 is of conventional construction and includes a brine inlet chamber 44, a nozzle 45 interposed between the brine inlet chamber and the lower chamber 14, and a throat 46 disposed between the brine inlet chamber and the lower outlet passage 19. The brine inlet chamber is connected through a pipe 48 and regenerant control valve 49 with a brine tank 50.

A main valve member 51 is provided for controlling the flow through the upper and lower seats 25 and 26 and includes opposed valve faces 52 and 53 which are respectively cooperable with the upper and lower seats. The valve member 51 is normally positioned as shown in FIG. 1 with the lower face 53 engaging the lower valve seat 26 to block flow therethrough whereby water from the inlet passes upwardly through the upper seat 25, flow chamber 13 and conduit 21 to the treatment tank 10. The treated water from the tank flows through the conduit 22, lower flow passage 19 and past check valve 35 to the service outlet 36. During regeneration, the valve member 51 is moved to a raised position blocking flow through the upper seat 25 to thereby pass raw water from the inlet 15 through the conduit 22 to the bottom of the treatment tank 10. The effluent from the treatment tank passes through the conduit 21 into the upper flow chamber 13, and a drain valve 63 is provided for selectively passing the effluent from the tank to drain. As shown in FIGS. 1 and 2, the casing 11 has a portion which extends upwardly from the chamber 13 and defines a drain valve chamber 61 having a drain outlet 62 and a valve seat 63 between the drain valve chamber and the drain outlet. A drain valve member 64 cooperates with the seat 63 to control the flow of liquid therethrough and is normally urged to a closed position by a spring 65 interposed between a flange 66 on the drain valve stem and a split ring 67 on the casing.

Heretofore, solenoid-type drain valves have been employed to control the flow of the backwash water to drain. Such solenoid-type valves have not been entirely satisfactory since stroke of the valves is relatively low so that the valves do not open very wide. During backwash, the effluent from the treatment tank frequently contains small particles of solids such as the exchange resins which become lodged between the solenoid operated drain valve and its seat and prevent reseating of the drain valve. Moreover, the force which can be exerted by the solenoids is relatively low and it is necessary to use relatively light springs to urge the solenoid operated valves closed, which light spring pressure also increased the likelihood of leakage through the drain valve.

It has been found that a heat motor, designated generally by the numeral 71, can be advantageously employed to operate the drain valves. Such heat motors can be economically provided, have a sufficiently long stroke to assure wide opening of the valve, and exert relatively high pressures to assure reliable operation. However, such heat motors are subject to damage due to excessive internal pressures, distortion and deterioration if the temperature rises above a predetermined temperature and difficulty has heretofore been encountered in properly limiting the temperature rise in the heat motors.

In accordance with the present invention, heat motor 71 is mounted so as to be cooled by the liquid flowing through the drain valve to drain. The heat motor includes a base 72 which is threadedly mounted on the upper end of the casing 11 and has a guide bore 73 there-

in for slidably receiving an actuator 74 connected to the stem of the drain valve. The heat motor also includes an expansion chamber 75 containing a thermally expansible material 76 and which expansion chamber has a rigid shell portion 77 and an expansible wall such as the diaphragm 78 which closes one end of the shell. The shell is firmly attached to the base in heat conducting relation therewith as by the ring 79 which is spun over flanges on the shell and base and, preferably, the casing 11 is formed with a recess 81 for receiving the ring 79 to more rapidly conduct the heat away from the heat motor. The expansible material 76 in the chamber 75 is selectively heated by a heating element 82 surrounding the shell and the expansion of the wall 78 is transmitted to the actuator 74 through a resilient plug 83. Thus, when the heater 82 is energized the material 76 expands and moves the actuator 74 to open the drain valve.

A typical curve illustrating the relation between the travel of the heat motor actuator 74 and the temperature of the expansible material 76 in the chamber 75 is shown in FIG. 3. The actuator does not begin to move the drain valve away from its seat (position P_1) until the temperature in the heat motor reaches a preselected minimum control temperature designated T_1. As the temperature of the heat motor rises, the actuator continues movement to its fully open position (P_2) as indicated by the curve C_1 until the heat motor reaches an upper control temperature designated T_2. Further heating of the heat motor above the temperature T_2 produces little additional movement of the actuator. However, at temperatures above about 250° F. (designated T_3 in FIG. 3), some deterioration and damage occurs to the heat motor due to excessive internal pressures and deterioration of the diaphragm 78 and expansion plug 83. The metal-to-metal contact area between the heat motor shell and the casing 11 is correlated with the heat output of the heater 82 and is made sufficiently large so that the fluid which flows through the portion of the casing 11 adjacent the heat motor, when the latter is energized, will cool the heat motor sufficient to prevent the temperature of the latter from rising above the range of safe operating temperatures, that is above the aforementioned temperature T_3. The amount of contact area for any particular heater can be best determined experimentally by increasing or decreasing the depth of the recess 81 to increase or decrease the area and hence the rate at which heat is conducted away from the heat motor. The control system specifically disclosed herein is of the type wherein the regenerant and rinse effluent as well as the backwash effluent flow upwardly through the tank to drain. The regeneration and slow rinse rates are relatively lower than the backwash rate and the contact area between the shell 75 and the valve casing is made sufficiently large to conduct the heat away during regeneration and slow rinsing at a sufficiently rapid rate to prevent the temperature of the heat motor from rising above 250°. Since the backwash rate is relatively higher, the backwash effluent will produce a somewhat greater cooling action on the heat motor as it flows to drain.

The heat motor can also be adapted to automatically regulate the backwash rate in accordance with the temperature of the backwash affluent, by interrelating the heat input to the heat motor by heater 82 and the heat conducted away from the heat motor so that the heat motor temperatures lie in the control temperature range of the heat motor, that is between the temperatures designated T_1 and T_2 during backwash.

In order to properly backwash the bed of exchange material in the treatment tank 10, it is necessary to provide the proper rate of flow during backwash to effect the desired expansion of the bed of exchange material without, however, having too high a backwash rate which would cause the exchange mineral to pass outwardly through the top of the treatment tank to drain. Further, the backwash rate necessary to provide proper bed expansion varies markedly with the temperature of the backwash water. For example, for the high efficiency polystyrene base-exchange resins the backwash rate should be such as to provide about sixty-five percent bed expansion. With the above material, this bed expansion will be achieved with a flow rate of four gallons per minute per cubic foot of exchange resin, when the temperature of the water is thirty-five degrees. However, a backwash rate of seven gallons per minute per cubic foot of exchange resin is required when the water temperature is seventy degrees. Thus, for installations in different localities having widely different water temperatures, and even for the same installation in which the seasonal variations in water temperature vary markedly, it is desirable to control the backwash rate in accordance with the temperature of the liquid. Since the heat motor 71 is cooled by the backwash water, and as the cooling effect decreases when the temperature of the backwash water increases, the heat motor will increase the opening of the drain valve as the temperature of the backwash water increases. By suitable selection of the expansible material and port areas, the increase or decrease in the rate of flow during backwash with changes in temperature of the backwash water can be varied to substantially maintai the desired bed expansion under varying temperature conditions.

The main valve 51 is automatically moved from its normal position to its regeneration position shown in FIG. 2 with response to opening of the drain valve 64. In the embodiment illustrated this is achieved by the provision of a head 91 which is attached to a stem 92 on the main valve. The head is interposed in the path of flow of the backwash water to the drain passage and a collar 93 closely surrounds the head to provide a restricted flow passage therebetween when the valve member is in its lower position. The underside 91*a* of the head is tapered to provide relatively more rapid flow thereby, when the valve member is in its raised position shown in FIG. 2. The heat motor and the solenoid 41 are conveniently controlled by a common timer 95. The timer is connected to the heat motor through conductors 96 and 97 and to the solenoid 41 through conductors 98 and 99.

The operation of the control system is as follows. During the normal service run, the valve 51 is in its lowered position blocking flow through the lower seat 26 whereby raw water flows to the top of the tank 21 and the treated water from the tank flows through the lower conduit 22 past check valve 35 to the service outlet 36. The timer 95 is arranged to automatically energize the heat motor after a certain time has elapsed corresponding to the normal service run of the treatment apparatus. Energizing of the heat motor opens the drain valve 64 and, the fluid flowing to drain past the head 91, raises the main valve to a position shown in FIG. 2 blocking flow through the upper seat 25. Raw water is then supplied to the lower flow chamber 14 and to the nozzle 45 of the ejector. The ejector draws brine from the tank 50 and passes the brine to the bottom of the treatment tank and out through the drain valve to drain. The ejector passes a relatively restricted flow of water to the treatment tank and the flow to drain during the brine injection step is relatively low. Consequently, the heat motor will operate to move the drain valve to a fully open position to assure maintaining of a low back pressure at the outlet of the ejector. As previously noted, the area of contact between the heat motor and the drain valve casing 11 and the size of the heater 82 are correlated so that the temperature rise of the heat motor, during the brining and slow rinse phases of the regeneration cycle will not cause damage to the heat motor. After a preselected quantity of brine has been introduced into the treatment tank, the brine control valve 49 closes and subsequent flow through the ejector effects a slow rinse of the bed of exchange material. Thereafter, a combined rapid rinse and backwash is effected by opening of the solenoid valve 41 under the control of the

timer 95. When the solenoid valve is opened, the pressures on opposite sides of the ejector are substantially equalized so that no flow occurs therethrough. The water then flows through the rinse port 33 and upwardly through the treatment tank 10 and out to drain. As previously described, the cooling of the heat motor and hence the opening of the drain valve is controlled by the rate of flow of water and also by the temperature of the water and the heat motor automatically increases the opening of the drain valve and hence the rate of flow to drain, when the temperature of the water increases to thereby maintain satisfactory expansion of the exchange bed in the tank 10.

The heat motors are relatively slow in operation since some time is required after energizing the heater before the temperature in the heat motor builds up sufficient to operate the valve. This time lag can be varied within limits by increasing or decreasing the heat output of the heater, it being apparent that increases in heat output of the heater require an increase in the contact area for conducting heat away from the heat motor to prevent overheating of the latter. However, such slow action is not important in connection with the control of a water treatment apparatus since it merely introduces a delay in the start of the regeneration cycle. The main valve 51 does not move up to its regeneration position until the drain valve has opened relatively wide sufficient to produce adequate flow past the head 91 to raise the valve member. So long as the valve member remains in its lower position there is insufficient pressure differential across the ejector to cause the latter to operate so that no brine is introduced until the valve member has moved to its raised position. However, the slow action of the heat motor in opening and closing valves is of advantage in the control of water apparatus since it prevents water hammer and provides quiet operation. The heat motors, when heated, exert very high pressures so that a heavy spring can be used to close the valve to assure reliable closing. Moreover, the stroke of such heat motors can be made relatively large to assure wide opening of the valve and thus prevents foreign material and resin from becoming lodged between the drain valve and its seat.

I claim:

1. A valve comprising a heat conducting metal valve body having an inlet passage and an outlet passage and a valve port intermediate said passages, a valve member for controlling flow through said port, means yieldably urging said valve member to one position, a valve operator including a rigid heat conducting metal shell closed at one end, a resilient expansible wall of non-heat conducting material closing the other end of said shell and defining a closed expansion chamber, a thermally expansible material in said shell, a plunger engaging said resilient wall and operatively engaging said valve member for moving the same to a second position when the expansible material is heated, means including an electrical heating element for heating the expansible material in the shell, and means mounting said other end of said shell on said valve body, said mounting means providing metal-to-metal contact between said other end of said shell and said valve body to form a heat conduction path between the shell and body for limiting heating of the former by the liquid flowing through the valve.

2. A heat motor operated valve for controlling the flow of a liquid having a temperature substantially below the temperature of the ambient air comprising, a heat conducting metal valve body having an inlet and an outlet, said valve body being adapted to be cooled by the liquid flowing therethrough, a valve member for controlling flow from the inlet to the outlet, means yieldably urging said valve member to its closed position, a heat motor of the type including a heat conducting metal shell closed at one end and having a resilient wall of non-heat conducting material closing the other end to define a closed expansion chamber, a plunger engaging said resilient wall and operatively engaging said valve member, a thermally expansible material in said shell operative when heated to an operating temperature range to move said plunger and open said valve member, electrical heater means operative to heat said shell above said operating temperature range, means mounting said shell on the valve body and providing a metal-to-metal heat conducting path therebetween sufficient to limit the temperature rise of the heat motor to said operaing range when liquid flows through the valve body.

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