CONTROL APPARATUS

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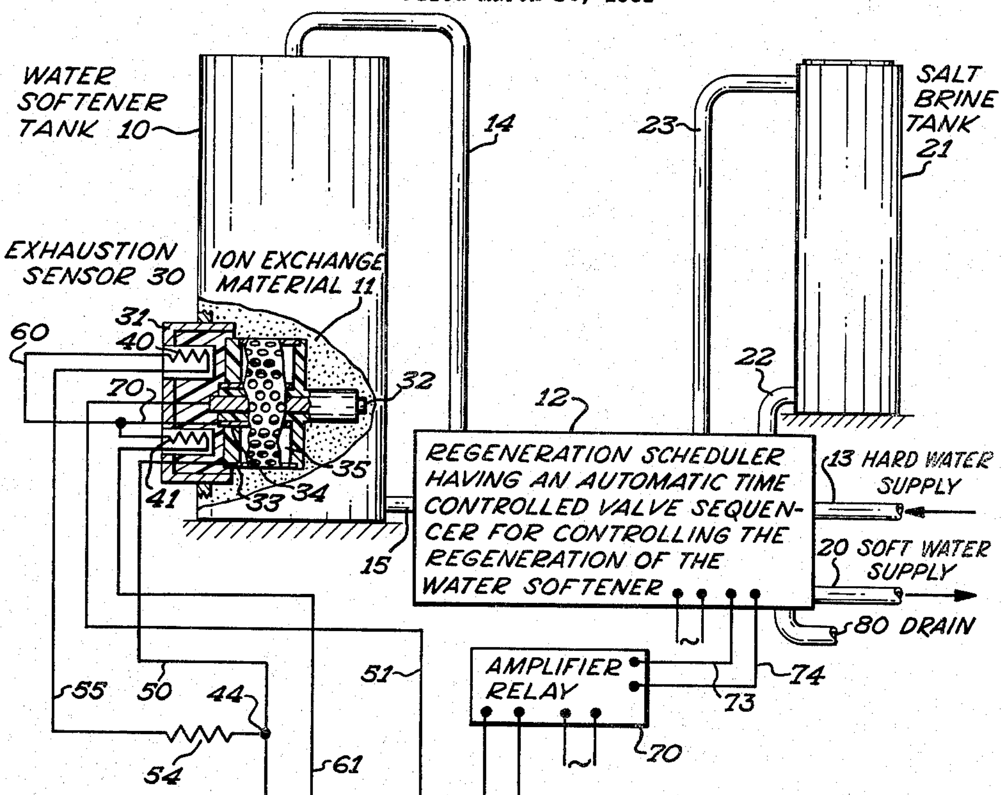

Fig 1

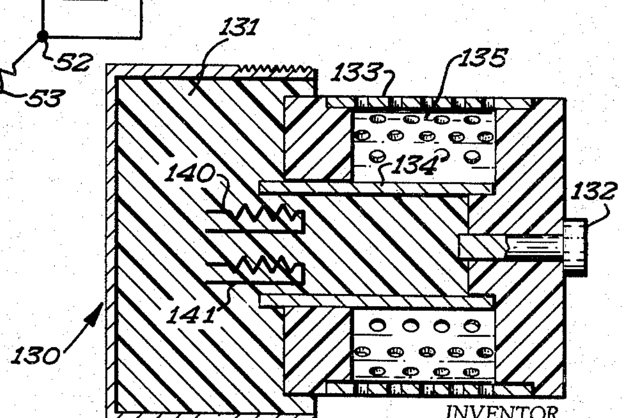

Fig 2

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CONTROL APPARATUS
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The present invention is concerned with an improvement in control apparatus for use with a water-softening system; in particular, the invention relates to the use of a device which senses the change in impedance of the ion exchange material used in the water softener wherein the effects of a change in impedance of the water due to temperature or ion concentration have no effect upon an output resulting from the change in impedance of the ion exchange material.

In the water-softening apparatus in which hard water is passed through a tank containing an ion exchange material for removing the "hard" ions from the water, the ion exchange material eventually needs to be recharged or regenerated. To recharge or regenerate the ion exchange material, salt or sodium "soft" ions are introduced into the ion exchange material passing salt water through the ion exchange material. There are various means of initiating the regeneration operation of a water softener. One of these means makes use of the change in impedance of the ion exchange material, and since the impedance of the water can change due to variations in the ion concentration or temperature, these parameters must be compensated for, to prevent a regeneration or recharging cycle when regeneration of the ion exchange material is not necessary.

In such control systems, the impedance of the ion exchange material surrounded by water is sensed by a pair of electrodes inserted into the water softener tank. Since the impedance of the water changes with variations in ion concentration or temperature, a second set of electrodes forming a water cell, which is associated with the water but separated from the ion exchange material, is used to offset the effect of the change in impedance of the water on the ion exchange material cell.

In order to have the water cell completely compensate for the effects of the change in impedance of the water on the output of the ion exchange material cell, the output of the water cell must be made to correspond with the output of the ion exchange material cell as affected by the parameters other than the impedance of the ion exchange material. Since the effect of the change in impedance of the water due to temperature is different than the change in impedance of the water due to changes in ion concentration, the network cannot be made to fully compensate for the effect of the water on the ion exchange material cell by the use of a single water cell.

The present invention is concerned with the use of at least one temperature responsive impedance means which responds to a temperature indicative of the temperature of the water. The output of the responsive means is used to modify the effect of temperature on the compensation for the changes in impedance of the water on the ion exchange material cell. Specifically, a bridge network has an ion exchange material cell in one branch of the circuit so that the impedance of the branch changes as the impedance of the ion exchange material changes or the impedance of the water changes due to variations in either ion concentration or temperature. A second branch of the bridge network has a water cell which responds to the impedance of the water as it changes due to changes in ion concentration or temperature. The second branch has its output modified by the impedance change of a network having a temperature responsive impedance element which senses the water temperature.

An object of the present invention is to provide an improved control apparatus for controlling the regeneration of a water softener wherein the regeneration cycle is controlled by the impedance of the ion exchange material and the impedance changes of the water due to variations in ion concentration or temperature are made ineffective.

Another object of the present invention is to provide an improved control apparatus for controlling the regeneration cycle of a water softener wherein a first sensor responds to the impedance of the ion exchange material and the water in a water softening tank, a second sensor responds to the impedance of the water as it changes due to a change in ion concentration or temperature, and a third sensor responds to the temperature of the water; so that, when the outputs of the three sensors are combined, no effect by any change in impedance of the water is obtained in controlling associated regeneration apparatus.

These and other objects of the present invention will become apparent upon the study of the specification and drawing, of which:

FIGURE 1 is a schematic drawing of a typical water softening system wherein a tank contains an ion exchange material and a sensor that responds to the effectiveness of the ion exchange material to initiate a regeneration cycle.

FIGURE 2 is a schematic showing of a second embodiment of a sensor.

Referring to FIGURE 1, a typical water softener system is shown. A tank **10** contains a water softening resin or ion exchange material **11**. The material is commonly available and has the characteristic of replacing certain "hard" elements or ions in the water, such as calcium, magnesium and other elements, by "soft" elements or ions, such as sodium which tends to reduce the hardness of the water. There are various organic and inorganic ion exchange materials or resins which exhibit a change in impedance as the soft ions are replaced by hard ions from the water. One common inorganic ion exchange material is commercially known as Zeolite; however, organic ion exchange materials are numerous and as well known.

A regeneration scheduler **12** is a typical valving apparatus for controlling the flow of water in the system in a predetermined manner. One typical scheduler is shown in the W. J. Hughes Patent 2,012,194 wherein a motor drives a plurality of cams for opening and closing various valves in the water softening system to provide a predetermined sequence of water flow in a time controlled manner. For example, during normal operation, hard water flows from the hard water supply through a pipe **13**, scheduler **12**, a pipe **14**, tank **10**, a pipe **15**, and back to a pipe **20** to supply soft water for domestic purposes or for whatever the soft water is used. Connected to the scheduler is a salt brine tank **21** for providing a flow of salt water when water flows through a pipe **22** into tank **21** to force the salt water out of the tank through a pipe **23**.

An exhaustion or ion exchange material sensor **30** is shown inserted in tank **10**. Sensor **30** comprises a base **31** which is screwed into tank **10**. The base carries a first electrode **32** which is mounted in the center of the base and projects from the base to be in contact with the ion exchange material and water in tank **10**. The second electrode **33** comprises a perforated cylindrical covering for a portion of the base. Electrode **33** is in contact with the ion exchange material in water in tank **10**. When electrodes **32** and **33** are electrically connected, an ion exchange material or resin cell is formed which measures the impedance of the ion exchange material, the water, and any other parameters which affect the impedance between electrodes **32** and **33**. A third electrode **34** comprises a cylindrical covering for a portion of base 31. Electrode 34 is separated from the ion exchange material by confining the electrode to a chamber 35 inside cylindrical electrode 33. Chamber 35 contains water which flows into the chamber to be in contact with electrode 34 through the perforations of electrode 33. When electrode 34 and electrode 33 are connected, a "water" cell is formed which provides an output as a measure of the impedance of the water due to ion concentration and other parameters.

A pair of temperature responsive impedance elements or thermistors 40 and 41 are mounted in base 31. The thermistors are subjected to the temperature of the base which is substantially the temperature of the water in tank 10. Obviously, the thermistors or some other suitable temperature responsive elements could be located in some other place to respond to the temperature of the water; however, the temperature of the water as close to the other electrodes 32, 33, and 34 should be measured for proper operation of sensor 30.

A bridge network circuit 42 is shown with a source of power 43 connected across terminals 44 and 45. Source of power 43 is a conventional step down transformer. Connected between terminals 44 and 45 are two branch circuits. A first branch circuit comprises the ion exchange material cell and is traced from terminal 44 through a conductor 50, electrode 33, the ion exchange material 11, electrode 32, a conductor 51, a terminal 52, a resistor 53, and back to terminal 45. A second branch is traced as follows: from terminal 44, a resistor 54, conductor 55, thermistor 40, a conductor 60, thermistor 41, a conductor 61, a resistor 62, a terminal 63, a resistor 64, and back to terminal 45. Connected in parallel with resistor 54 and thermistor 40 is the water cell as traced from conductor 60, conductor 70, electrode 34, electrode 33, and back to terminal 44.

An output is available from network circuit 42 between terminals 52 and 63. The output is connected to an amplifier relay 70 by conductors 71 and 72. The amplifier relay 70 is of a conventional type such as disclosed in the Wilson Patent 2,420,578. When the output of the network circuit 42 reaches a predetermined value, the output is amplified to control the operation of a relay for closing a circuit between conductor 73 and conductor 74 connected to scheduling device 12. When the circuit is closed, the scheduling device is started to run the regeneration operation through a complete cycle to regenerate the ion exchange material 11 in the tank 10. While the network circuit 42 is shown as a conventional circuit, there are other types of circuits which would be equally applicable for comparing electrical signals and providing an operation of a circuit closing means when a predetermined unbalance of the signal exists. For example, resistors 53 and 64 may be replaced by the coils of a balance type relay.

Referring to FIGURE 2, a second embodiment of an exhaustion sensor 130 is shown. The sensor has a body 131 for supporting an electrode 132 which is in contact with the water and ion exchange material when the sensor is inserted in a water softener tank. An electrode 133 which is made up of a perforated cylindrical member surrounding body 131 is also in contact with the ion exchange material and water. Electrodes 132 and 133 are adapted to be connected to make up an ion exchange material cell. Electrode 134 which comprises a cylindrical member mounted in chamber 135 is in contact with the water only as the water is able to flow through the perforations of electrode 133. When electrodes 133 and 134 are connected, a "water" cell is formed. A pair of temperature responsive elements or thermistors 140 and 141 are shown mounted in base 131 to respond to the temperature of the base and thus to the temperature of the water to which electrodes 132, 133, and 134 are exposed.

Operation

The recharging or regeneration operation of a water softener is quite conventional. After the hard water flowing from supply 13 through pipe 14 into tank 10 has delivered a certain amount of soft water from pipe 15 to the soft water supply pipe 20, the impedance of the ion exchange material 11 in tank 10 will change. When the impedance of the ion exchange material reaches a predetermined value, the effectiveness of the ion exchange material is depleted and a regeneration operation is needed. Upon the energization of relay 70, the scheduling device 12 is initiated to provide a valving sequence to recharge the ion exchange material in the following manner over a predetermined period of time. Once device 12 is energized, a complete regeneration cycle is made before sensor 30 is again placed in control of scheduler 12. Hard water from supply 13 is passed back through tank 10 by way of pipe 15 and pipe 14 to a drain 80 to flush out the foreign deposits in the tank. After a predetermined backwash operation, the hard water supply 13 is connected to pipe 22 to deliver salt water from pipe 23 into the tank through pipe 14. The salt water passes through tank 10 and out of drain 80. When the salt water is in contact with ion exchange material 11, the hard ions collected in the ion exchange material are replaced by soft ions so the ion exchange material is recharged. A further operation of the scheduling device provides for the rinsing of all the salt out of tank 10 by supplying hard water from pipe 13 through pipe 14 so the excess salt water is passed out of the drain 80.

Since the impedance of the ion exchange material is measured by the impedance between electrodes 32 and 33, the output of circuit 42 is effective to commence the regeneration operation whenever the impedance of the material reaches some predetermined value. Since the impedance between the electrodes 32 and 33 is also affected by the impedance of the water as well as other parameters, the impedance of the water must be taken into account. A water cell made up of electrodes 34 and 33 is connected into network circuit 42 to oppose the impedance of the ion exchange material. Since the water cell impedance which is determined by the impedance of the water itself must be made to exactly compensate for the effect of the water impedance, the effects of a change in temperature on the impedance of water is not completely compensated. By means of thermistors 40 and 41, the characteristics of the water cell made up of electrodes 33 and 34 are modified to have an output which can be used to compensate for the effects of the change in impedance of the water due to either ion concentration or temperature on the resin cell.

An increase in temperature of the water and ion exchange material results in an increase in the resistance of both the water and the ion exchange material. The relative resistance or impedance of the water and ion exchange material has quite a spread as the water resistance is quite high and the ion exchange material or resin has a very low resistance. While the change in resistance for a given temperature change may be the same percentage for both the water and resin, when the two resistances are connected in parallel, the effect of the change in temperature upon the combined resistance is not linear. The resistance between electrodes 32 and 33 due to the ion exchange material 11 is rather low and the resistance due to the water is high. When the temperature of the water and thus the temperature of the ion exchange material increases, the resistance of both the ion exchange material and the water may drop but the combined resistance between electrodes 32 and 33 is not proportional to the change in resistance of the water alone as would be measured by the resistance between electrodes 33 and 34 for the same temperature change. The relative size of electrode 32 of the resin cell and electrode 34 of the water cell has been selected to more effectively match the cells to have a similar change in resistance as temperature changes, but the best match is not obtained with the water cell alone. By placing the thermistors 40 and 41 which have a negative temperature coefficient of resistance in the circuit with the electrodes 33 and 34, the resistance change between conductor 61 and terminal 44 has a characteristic similiar to the resistance change of the water and resin between electrodes 32 and 33 as effected by a change in temperature whereby the output of sensor 30 is only a measure of the change in resistance of the ion exchange material 11 due to a change in its ion content.

The importance of the applicant's contribution to the water softening control system is quite significant since a regeneration control device must be made to control the regeneration process whenever the impedance of the ion exchange material reaches some predetermined value. If some other parameter affects the impedance measurement, the regeneration process may be started too soon or too late which can have detrimental effects upon the ion exchange material as well as the bringing about of unnecessary regeneration operation. When a control apparatus having the sensor 30 is used, the softener can be placed in any locality which might have a water which changes in ion concentration and in temperature throughout the seasons. As the temperature and ion concentration of the water changes, the impedance change due to these parameters would have no effect upon the measurements of the impedance of the ion exchange material.

The operation of the system with exhaustion sensor 130 as shown in FIGURE 2, when connected in the network of FIGURE 1, is the same as exhaustion sensor 30. The sensor 130 is adapted to be screwed into the side of a water softening tank, and electrodes 132, 133, and 134 would be connected to the network support 42 in the same manner as electrodes 32, 33, and 34 of sensor 30. Thermistors 140 and 141 are also adapted to be connected into a support such as support 42 in FIGURE 1 in the same manner as thermistors 40 and 41 of exhaustion sensor 30.

While the invention has been described in one particular manner, the intention is to limit the scope of the invention only by the appended claims of which I claim:

1. In a control system for controlling the regeneration operation of a water softener wherein an ion exchange material which changes in impedance is used to soften water as water passes therethrough, an electrical network circuit having two branches and an output circuit which has an output signal depending upon the relation of the impedance of said branches, first and second electrodes mounted in the ion exchange material and water of the water softener to be responsive to the impedance of the ion exchange material and the water in the softener, means connecting said first and second electrodes in said first branch, a third electrode mounted in a chamber connected to contain only water from the softener, said second and third electrodes being responsive to the impedance of the water in the softener, said first electrode having a smaller area than said third electrode, a temperature responsive means having an impedance which varies with temperature, said temperature responsive means being mounted to respond to the temperature of the water and ion exchange material in the softener, means connecting said second and third electrodes and said responsive means in said second branch whereby the effects of changes of the impedance of the water due to changes in ion concentration or temperature and of the impedance of the ion exchange material due to changes in temperature can be compensated and said output is determined only by the impedance change of the ion exchange material due to a change in ion content, control means adapted to control the regeneration cycle of the water softener, and means connecting said output circuit to said control means to start the regeneration operation when the impedance of the ion exchange material reaches a predetermined value.

2. In a control system for controlling the regeneration operation of a water softener wherein an ion exchange material which changes in impedance is used to soften water as water passes therethrough, an electrical network circuit having two branches and an output circuit which has an output signal depending upon the relation of the impedance of said branches, first impedance responsive means responsive to the impedance of the ion exchange material and the water in the softener, means connecting said first means in said first branch, second impedance responsive means responsive to the impedance of the water in the softener, first and second temperature responsive means having an impedance which varies inversely with temperature, said first and second responsive means being mounted to respond to the temperature of the water in said softener, means connecting said first temperature responsive means in series with said second impedance responsive means in said second branch, means connecting said second temperature responsive means in parallel with said second impedance responsive means whereby the effects of changes of the impedance of the water due to changes of molalities and temperature on said first impedance responsive means can be compensated and said output is determined only by the impedance change of the ion exchange material due to a change in ion content, and control means adapted to control the regeneration cycle of the water softener, and means connecting said output circuit to said control means to start the regeneration operation when said output reaches a predetermined value.

3. In a control system for controlling the regeneration of a water softener having a bed of ion exchange material through which water flows, first electrode means mounted in said bed and responsive to the impedance of the ion exchange material and the water in said softener, second electrode means mounted in said bed and responsive to the impedance of only the water in said softener, third means responsive to the temperature of the water and ion exchange material in said softener, a regeneration apparatus for said water softener, control means adapted to control a regeneration operation of said apparatus of said softener, and electrical circuit means connecting said first, second, and third means to said control means and adapted to compensate for the effects of a change in temperature and ion content of the water and the effect of temperature on the ion exchange material whereby said regeneration apparatus is placed in operation when the ion exchange material reaches a predetermined impedance indicative of the depletion of its water softening capabilities.

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