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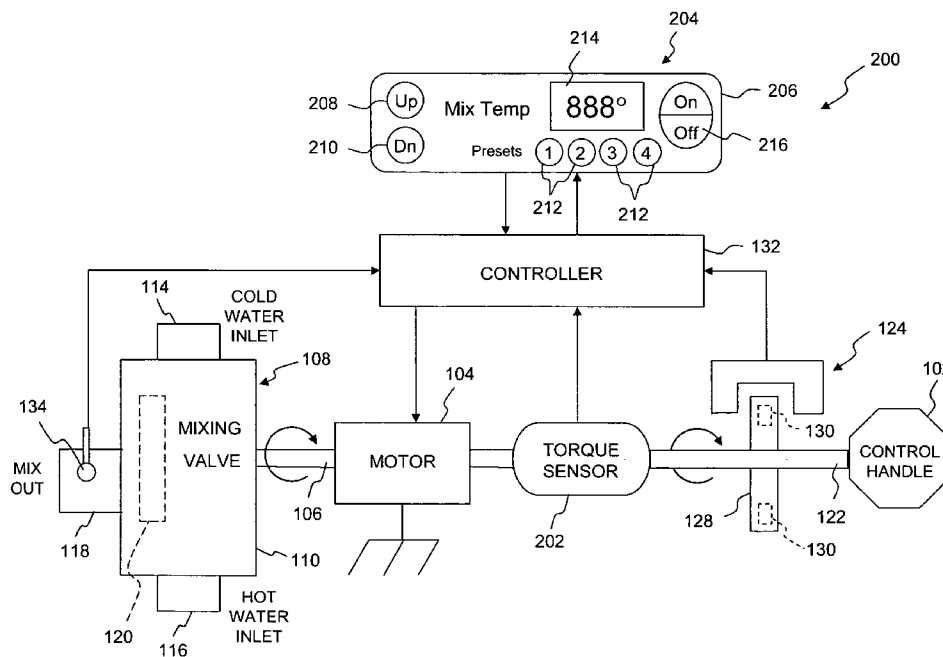
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(54) Title: ELECTRONIC MIXING VALVE ASSEMBLY



(57) Abstract: An electronic mixing valve assembly (100, 200) including a valve member (120) automatically controlled through a drive motor (104) and manually controlled through a manual control handle (102).

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## ELECTRONIC MIXING VALVE ASSEMBLY

### BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates generally to an apparatus for controlling operation of a shower valve and, more particularly, to a user interface facilitating operation of an electronic mixing valve.

Conventional user interfaces for electronic shower valves often include push button controls which are non-intuitive. The present disclosure details an electronic mixing valve that facilitates manual operation of a shaft by the user. More particularly, the electronic mixing valve of the present disclosure is configured to provide an intuitive and familiar interface for normal valve operation similar to conventional manual shower valves while maintaining the convenience and benefits afforded by electronic control. The electronic mixing valve of the present disclosure is further configured to provide a substantially seamless method of providing manual override in the event of power loss or electronic system component failure.

According to an illustrative embodiment of the present disclosure, an electronic mixing valve assembly includes a valve body having a cold water inlet, a hot water inlet, and a mixed water outlet. A movable valve member is supported within the valve body and is configured to control the flow of water from the cold water inlet and the hot water inlet to the mixed water outlet. A manually operated handle is operably coupled to the valve member and is configured to be moved to a position corresponding to a desired water temperature or flow. A drive motor is configured to be operably coupled to the valve member. A manual control position sensor cooperates with the handle and is configured to detect the position of the handle. A controller is in communication with the position sensor and the drive motor. A temperature sensor is configured to detect the temperature of water in the mixed water outlet and is in communication with the controller. The controller establishes a set-point temperature based upon the position of the handle as the temperature detected by the temperature sensor has stabilized, and maintains the set-point temperature by controlling the drive motor.

According to a further illustrative embodiment of the present disclosure, an electronic mixing valve assembly includes a valve body having a first water inlet and a water outlet. A movable valve member is supported within the valve body and is configured to control the flow of water from the water inlet to the water outlet. A

manually operated handle is supported for rotation, and a drive motor is operably coupled to the valve member. A torque sensor is operably coupled to the handle and is configured to detect torque applied by rotation of the handle. A controller is in communication with the torque sensor and the drive motor. The controller causes the drive motor to move the valve member in response to torque detected by the torque sensor.

According to yet another illustrative embodiment of the present disclosure, an electronic mixing valve assembly includes a valve body having a first water inlet and a water outlet. A movable valve member is supported within the valve body and is configured to control the flow of water from the water inlet to the water outlet. A manually operated handle is supported for rotation. The electronic mixing valve further includes a drive motor and a transmission member configured to simultaneously operably couple both the manually operated handle and the drive motor to the valve member. A sensor is configured to detect user input applied to the manually operated handle. A controller is in communication with the sensor and the drive motor, wherein the controller causes the drive motor to adjust the valve member in order to maintain a set-point temperature defined by the relative position of the manually operated handle.

Additional features and advantages of the present invention will become apparent to those skilled in the art upon consideration of the following detailed description of the illustrative embodiment exemplifying the best mode of carrying out the invention as presently perceived.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description of the drawings particularly refers to the accompanying figures in which:

Fig. 1 is a diagrammatic view of a prior art electronic mixing valve assembly including a user interface;

Fig. 2 is a diagrammatic view of an electronic mixing valve assembly according to an illustrative embodiment of the present disclosure;

Fig. 3 is a flow chart showing an illustrative method of operation of the electronic mixing valve assembly of Fig. 2; and

Fig. 4 is a diagrammatic view of an electronic mixing valve assembly according to a further illustrative embodiment of the present disclosure.

#### DETAILED DESCRIPTION OF THE DRAWINGS

5 Referring initially to Fig. 1, a prior art electronic mixing valve system or assembly 10, including an user interface 12 is shown. The user interface 12 includes temperature set-point control buttons 14 and 16 configured to control the establishment of a temperature set-point by operation of a controller 18. An ON/OFF button 20 is provided to activate and deactivate the mixing valve assembly 10. A  
10 temperature display 22 is provided and may include a liquid crystal display (LCD). The control buttons 14, 16, ON/OFF button 20, and water temperature display 22 are illustratively supported on a user control pad 24.

Pressing the control buttons 14, 16 will increase or decrease, respectively, the desired water temperature and program the temperature set-point data into controller  
15 18. A temperature sensor 26 is mounted at the mixed water outlet 28 of a mixing valve 30 and is configured to provide feedback for the controller 18. A drive motor 32 controls the valve 30 in order to provide the desired temperature set-point by adjusting the mix of water supplied to the mixed water outlet 28 from cold water inlet 34 and hot water inlet 36.

20 Referring now to Fig. 2, an illustrative embodiment of the present disclosure is shown as including an electronic mixing valve system or assembly 100 adapted to be controlled using a traditional manually rotated operator knob or handle 102 in a manual mode of operation and using an electronically activated drive motor 104 in an automatic mode of operation. While the motor 104 illustratively comprises a stepper  
25 motor, any suitable actuator may be substituted therefor, including servo motors, DC motors and AC motors. A common transmission member, illustratively a rotatable shaft 106, operably couples a mixing valve assembly 108 simultaneously with both the motor 104 and the handle 102.

The valve 108 includes a valve body 110 having a cold water inlet 114 and a  
30 hot water inlet 116 in fluid communication with a mixed water outlet 118. A valve member 120 is movably supported within valve body 110 to control the flow of water from the cold water inlet 114 and the hot water inlet 116 to the mixed water outlet 118. As such, the valve member 120 controls the flow and the temperature of the mixed

water flowing through outlet 118. The valve member 120 is operably coupled to the shaft 106, and therefore to the motor 104 and to the handle 102.

The valve 108 may be of conventional design and include any one of a variety of mixing valves available on the market. One such mixing valve is shown in U.S. Patent No. 4,854,498, the disclosure of which is expressly incorporated by reference  
5 herein.

A handle transmission member, illustratively a rotatable shaft 122, operably couples handle 102 with motor 104. In one illustrative embodiment, motor 104 is a double shaft motor such that shafts 106 and 122 are axially aligned and coupled for  
10 simultaneous movement. In other words, rotation of shaft 122 results in corresponding movement of shaft 106 such that rotation of handle 102 results in movement of valve member 120. While the shafts 106 and 122 are configured to rotate valve member 120, it should be appreciated that sliding or axial movement  
15 along the longitudinal axes of the shafts 106 and 122 may be substituted for moving valve member 120.

A manual input sensor 124, illustratively an angular or rotary position sensor, is configured to detect user input applied to the handle 102. In an illustrative embodiment, the rotary position sensor 124 is operably coupled to a rotary position sensing device 126 supported by the shaft 122. Illustratively, the sensor 124 may  
20 comprise a Hall-effect sensor and the device 126 may comprise a disc 128 supporting a plurality of magnets 130. The Hall-effect sensor may determine the angular or rotational position of the disc 128 and hence shaft 122 based upon the detection of magnets. It should be appreciated that other sensors or encoders may be used for sensor 124 and device 126. Further, other types of sensors configured to detect user  
25 input applied to the handle 102 may be used instead of, or in addition to, the rotary position sensor 124. For instance, a torque sensor or a capacitive touch sensor may be used to provide an indication of manual input from the user applied to the handle 102.

Rotary position sensor 124 provides a digital signal to a controller 132 that indicates the water temperature desired by the user. The controller 132 utilizes the  
30 signal indicative of the desired temperature to establish a set-point temperature.

A temperature sensor 134, such as a thermistor, is in thermal communication with the mixed water passing through the outlet 118. More particularly, the temperature sensor 134 provides a signal indicative of the mixed water temperature to

the controller 132. Controller 132 compares the set-point temperature, as detected by the temperature sensor 134 following manual adjustment as indicated by the angular position sensor 124, and adjusts the drive motor 104 to maintain the desired set-point temperature.

5           A clutch mechanism (not shown) may be used to release a locked gear drive of the drive motor 104 when manual control of the valve member 120 is required (i.e., manual mode of operation). Alternatively, a double-axle shaft stepper motor arrangement could be utilized. One shaft 106 drives the valve member 120, while the opposing shaft 122 connects to the control handle 102. During manual operation, the  
10 field windings (not shown) within motor 104 may be released, allowing manual control of the valve member 120 via the operator handle 102. When automatic control is required, the field windings may be re-engaged, and the controller 132 returns to an automatic mode, illustratively a stepping (either one-half or micro-step) mode. In a further illustrative embodiment, a rotationally loose coupling may be  
15 provided to allow the shafts 106, 122 to be adjusted without substantial resistance or conflicting rotational movement from the motor 104.

With reference now to Fig. 3, an illustrative method of operation begins at block 150 with a user activating the mixing valve 100 by turning the manual handle 102 to either a visual positional temperature set-point or by sampling the mixed  
20 temperature by hand. At this point, the electronic controller 132 is inactive. At block 152, the controller 132 determines, based upon a signal received from the sensor 124, whether the manual handle 102, and hence shaft 122, is being rotated by user input. More particularly, the controller 132 determines through input from rotary position sensor 124 whether the shaft 122 is being moved independently, or without assistance,  
25 from the motor 104. Alternatively, the controller 132 could determine whether user input is applied to the handle 102 through signals received from a torque sensor or a touch sensor. In other words, and as noted above, the sensor 124 may be a rotary position sensor, a touch sensor, or a torque sensor.

If the controller 132 determines that no rotation of the handle 102 occurred,  
30 then the process returns to immediately before block 152. If the handle 102 has been rotated, then the valve member 120 is adjusted accordingly. More particularly, the motor 104 is illustratively released from shafts 106, 122, such that rotation of handle 102 moves valve member 120 with little or no resistance from motor 104. When the

user releases the valve control handle 102, the controller 132 detects this event at block 156 by input from sensor 124. More particularly, this event may be detected either through the delay of input from the sensor 124 or by lack of input from a touch sensor or a torque sensor coupled to the handle 102. When the controller 132  
5 recognizes this event, it assumes the mixed temperature is at the desired value and stores the current mixed temperature measured by sensor 134 as the target set-point temperature at block 158. At block 160, the controller 132 begins controlling the motor 104 to maintain the mixed temperature proximate to the target set-point temperature.

10 At this point, the control valve 100 behaves generally as a conventional electronic thermostatic valve. More particularly, if the mixed temperature should drift or deviate from the stored target set-point temperature, the controller 132 at block 162 engages the motor 104 in the appropriate direction and speed to compensate for the error and bring the mixed temperature back to the desired set-point temperature, after  
15 which the motor 104 disengages to allow the handle 102 to rotate freely to allow new set-point temperature changes to occur. If, as usual during normal operation, the user wishes to readjust the set-point temperature, then he simply rotates the temperature control handle 102 to a new position. As soon as the controller 132 determines through the rotary position sensor 124 (or through a touch sensor or a torque sensor  
20 input as detailed herein) that the shaft 122 is being moved without the aid of the motor 104 (block 164), it relinquishes control of the shafts 106, 122 to the user to define a new set-point temperature. Again, when the user releases the handle 102 at block 156 and the controller 132 detects the user has released, it then resumes control using the current temperature as the new set-point temperature by returning to block 158.

25 A touch or torque sensor may be used to detect user input or intervention rather than the rotary position sensor 124, since the possibility exists that the user may like to make adjustments at the same moment the motor 104 is engaged by the controller 132 attempting to control set-point temperature. This would result in the two systems (human and electronic) fighting for control. Using a rotary position  
30 sensor 124, the user may need to physically overpower the motor 104 in order for the controller 132 to detect asynchronous inputs from the motor 104 and the position sensor 124.

Illustratively, the electronic system (i.e. motor 104) relinquishes control whenever the user makes a set-point temperature change and then regains it immediately as soon as the input is released and relinquished.

In the event of electronics, motor or sensor failure, the controller 132 simply  
5 shuts down input to the motor 104. No other manual input is necessary to provide for manual operation. The mixing valve assembly 100 simply behaves like a conventional unregulated mixing valve.

With reference now to Fig. 4, a further illustrative embodiment electronic mixing valve system or assembly 200 is shown. The mixing valve assembly 200  
10 includes many of the same features detailed herein with respect to electronic mixing valve assembly 100. As such, similar components are identified by like reference numbers.

As shown in Fig. 4, a torque sensor 202 is positioned intermediate the control handle 102 and the motor 104. More particularly, the torque sensor 202 is operably  
15 coupled to the shaft 122 and is configured to detect the magnitude and direction of torque therein.

Electronic mixing valve assembly 200 also includes a user interface 204 including a control pad 206 having user input buttons to provide for additional input from the user. The control pad 206 illustratively includes an up button 208 and a  
20 down button 210 which may be depressed by the user to raise and lower, respectively, the set-point temperature. A plurality of preset buttons 212 are also provided and may provide preset set-point temperatures to the controller 132 when depressed. A temperature indicator, illustratively a liquid crystal display 214, provides for a visual indication of the temperature detected by the temperature sensor 134. An ON/OFF  
25 button 216 is provided to activate or deactivate the valve assembly 200.

With further reference to Fig. 4, in operation the user illustratively opens the valve 108 by rotating the control handle 102 and hence shaft 122. The torque sensor 202 provides a signal of torque in shaft 122 to the controller 132 which, in response, energizes the motor 104 to rotate shaft 122 in the same direction. In other words, the  
30 controller 132 adjusts the motor 104 in an attempt to minimize torque in shaft 122. Moreover, the motor 104 is energized to follow the direction and the speed of the control handle 102. This results in corresponding rotation of shaft 106 and adjustment of valve member 120. In other words, the torque minimization process performed by

the controller 132 results in opening the valve 108 or adjusting temperature by movement of valve member 120, and provides for consistent easy operation of the valve 108. When a user releases the handle 102, the torque drops and the controller 132 releases the motor 104. The controller 132 then stores the set-point temperature  
5 as indicated by the temperature sensor 134. The valve assembly 200 now behaves as a conventional electronic mixing valve using the stored mixed temperature as the set-point and adjusting the temperature by controlling the motor 104 as necessary.

When the user wishes to readjust the temperature or turn the valve off, he again turns the control handle 102. In response, the torque sensor 202 sends a signal  
10 to the controller 132. The signal provides an indication of the torque magnitude and direction. Again, the controller 132 rotates the motor 104 in the same direction attempting to minimize torque within the shaft 122. The rotary position sensor 124 is optional, but may be included to aid in defining the temperature set-point without the need to wait for the mixed temperature to reach the sensor 134.

15 In the event of power loss or electronic component failure, the controller 132 releases the motor 104 allowing it to free-wheel. In other words, the shafts 106, 122 are free to rotate with little or no resistance from the motor 104. Thus without any necessary override changeover, the valve assembly 200 can be used as a conventional mixing valve without temperature or pressure balance compensation. Using the valve  
20 assembly 200 allows for simple intuitive operation similar to conventional manual valves while allowing full electronic control and the associated benefits plus manual override without user intervention.

Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the spirit and scope  
25 of the invention as described and defined in the following claims.

## CLAIMS:

1. An electronic mixing valve comprising:
  - a valve body including a cold water inlet, a hot water inlet, and a mixed water outlet;
  - a movable valve member supported within the valve body and configured to control the flow of water from the cold water inlet and the hot water inlet to the mixed water outlet;
  - a manually operated handle operably coupled to the valve member, the handle configured to be moved to a position corresponding to a desired water temperature;
  - a drive motor configured to be operably coupled to the valve member;
  - a manual control position sensor cooperating with the handle and configured to detect the position of the handle;
  - a controller in communication with the position sensor and the drive motor;
  - a temperature sensor configured to detect the temperature of water in the mixed water outlet and in communication with the controller; and
  - wherein the controller establishes a set-point temperature based upon the position of the handle as the temperature detected by the temperature sensor has stabilized, and maintains the set-point temperature by controlling the drive motor.
2. The electronic mixing valve of claim 1, wherein the drive motor comprises one of a stepper motor and a servo motor.
3. The electronic mixing valve of claim 1, wherein the drive motor comprises one of a DC motor and an AC motor.
4. The electronic mixing valve of claim 1, wherein the drive motor is positioned intermediate the valve member and the manually operated handle.
5. The electronic mixing valve of claim 4, further comprising a first rotatable shaft operably coupled to the motor and the valve member, and a second rotatable shaft operably coupled to the motor and the handle.
6. The electronic mixing valve of claim 1, further comprising a rotatable shaft operably coupled to the handle and valve member, the position sensor comprising a rotational position sensor configured to detect the rotational position of the shaft.

7. The electronic mixing valve of claim 1, further comprising an electronic control interface operably coupled to the controller and including a temperature indicator configured to display the temperature of water detected by the temperature sensor.

8. The electronic mixing valve of claim 7, wherein the electronic control interface includes input buttons for adjusting temperature of water supplied to the mixed water outlet.

9. The electronic mixing valve of claim 1, wherein the motor is operably coupled to the valve member in an automatic mode and is uncoupled from the valve member in a manual mode.

10. The electronic mixing valve of claim 9, wherein the motor includes field windings that are released in the manual mode.

11. An electronic mixing valve comprising:  
a valve body including a first water inlet and a water outlet;  
a movable valve member supported within the valve body and configured to control the flow of water from the water inlet to the water outlet;  
a manually operated handle supported for rotation;  
a drive motor operably coupled to the valve member;  
a torque sensor operably coupled to the handle and configured to detect torque applied by rotation of the handle;  
a controller in communication with the torque sensor and the drive motor; and

wherein the controller causes the drive motor to move the valve member in response to torque detected by the torque sensor.

12. The electronic mixing valve of claim 11, further comprising a temperature sensor operably coupled to the controller and configured to detect the temperature of water supplied to the outlet, wherein the controller establishes a set-point temperature when the temperature has stabilized, and maintains the set-point temperature by controlling the drive motor.

13. The electronic mixing valve of claim 11, wherein the valve body includes a second water inlet, the first water inlet configured to receive a cold water, the second water inlet configured to receive a hot water, and the valve member being

configured to control the mix of water from the first water inlet and the second water inlet to the water outlet.

14. The electronic mixing valve of claim 11, further comprising an angular position sensor operably coupled to the controller and configured to detect an angular position of the handle.

15. The electronic mixing valve of claim 14, further comprising a rotatable shaft operably coupled to the handle and valve member, the angular position sensor configured to detect the angular position of the shaft.

16. The electronic mixing valve of claim 14, wherein the angular position of the handle is associated with a set-point temperature, such that the angular position sensor defines a set-point temperature.

17. The electronic mixing valve of claim 11, wherein the drive motor comprises one of a stepper motor and a servo motor.

18. The electronic mixing valve of claim 11, wherein the drive motor comprises one of a DC motor and an AC motor.

19. The electronic mixing valve of claim 11, further comprising a rotatable shaft operably coupled to the manually operable handle, wherein the torque sensor is configured to detect torque within the rotatable shaft.

20. The electronic mixing valve of claim 11, wherein the drive motor is positioned intermediate the valve member and the manually operated handle.

21. The electronic mixing valve of claim 19, wherein the torque sensor is positioned intermediate the drive motor and the manually operated handle.

22. The electronic mixing valve of claim 20, further comprising a first rotatable shaft operably coupled to the motor and the valve member, and a second rotatable shaft operably coupled to the motor and the handle.

23. The electronic mixing valve of claim 22, wherein the torque sensor is configured to detect torque within the second rotatable shaft.

24. The electronic mixing valve of claim 11, further comprising an electronic control interface operably coupled to the controller and including a temperature indicator.

25. The electronic mixing valve of claim 24, wherein the electronic control interface includes input buttons for adjusting temperature of water supplied to the water outlet.

26. The electronic mixing valve of claim 11, wherein the motor is operably coupled to the valve member in an automatic mode and is uncoupled from the valve member in a manual mode.

27. The electronic mixing valve of claim 26, wherein the motor includes field windings that are released in the manual mode.

28. The electronic mixing valve of claim 11, wherein the manually operated handle is operably coupled to the valve member.

29. An electronic mixing valve comprising:  
a valve body including a first water inlet and a water outlet;  
a movable valve member supported within the valve body and configured to control the flow of water from the water inlet to the water outlet;  
a manually operated handle supported for movement;  
a drive motor;  
a transmission member configured to simultaneously operably couple both the manually operated handle and the drive motor to the valve member;  
a sensor configured to detect user input applied to the manually operated handle;  
a controller in communication with the sensor and the drive motor; and  
wherein the controller causes the drive motor to adjust the valve member in order to maintain a set-point temperature defined by the relative positioning of the manually operated handle.

30. The electronic mixing valve of claim 29, wherein the manually operated handle is supported for rotation, and the sensor comprises a rotational position sensor cooperating with the handle and configured to detect the rotational position of the handle.

31. The electronic mixing valve of claim 30, further comprising a temperature sensor configured to detect the temperature of water at the water outlet and in communication with the controller, wherein the controller establishes a set-point temperature based upon the angular position of the handle as the temperature detected by the temperature sensor has stabilized, and maintains the set-point temperature by controlling the drive motor.

32. The electronic mixing valve of claim 29, wherein the manually operated handle is supported for rotation, and the sensor comprises a torque sensor

operably coupled to the handle and configured to detect torque applied by rotation of the handle.

33. The electronic mixing valve of claim 32, wherein the controller causes the drive motor to move to valve member in response to torque detected by the torque sensor.

34. The electronic mixing valve of claim 29, further comprising a temperature sensor operably coupled to the controller and configured to detect the temperature of water supplied to the outlet, wherein the controller establishes a set-point temperature when the temperature has stabilized, and maintains the set-point temperature by controlling the drive motor.

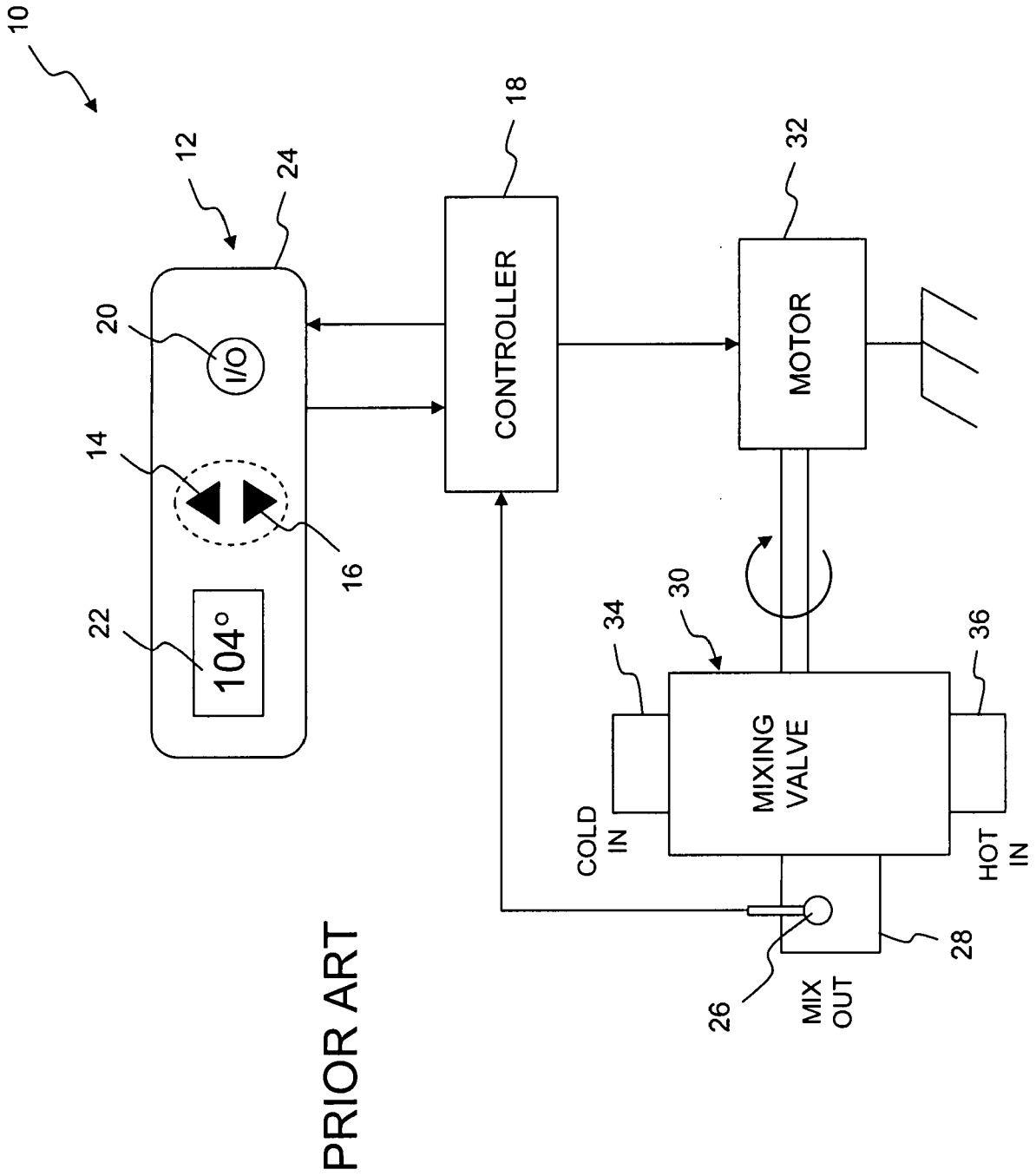
35. The electronic mixing valve of claim 29, wherein the valve body includes a second water inlet, the first water inlet configured to receive a cold water, the second water inlet configured to receive a hot water, and the valve member being configured to control the mix of water from the first water inlet and the second water inlet to the water outlet.

36. The electronic mixing valve of claim 29, further comprising a first rotatable shaft operably coupled to the motor and the valve member, and a second rotatable shaft operably coupled to the motor and the handle.

37. The electronic mixing valve of claim 29, wherein the motor is operably coupled to the valve member in an automatic mode and is uncoupled from the valve member in a manual mode.

38. The electronic mixing valve of claim 37, wherein the motor includes field windings that are released in the manual mode.

39. The electronic mixing valve of claim 29, wherein the sensor comprises a capacitive touch sensor configured to detect user contact with the handle.



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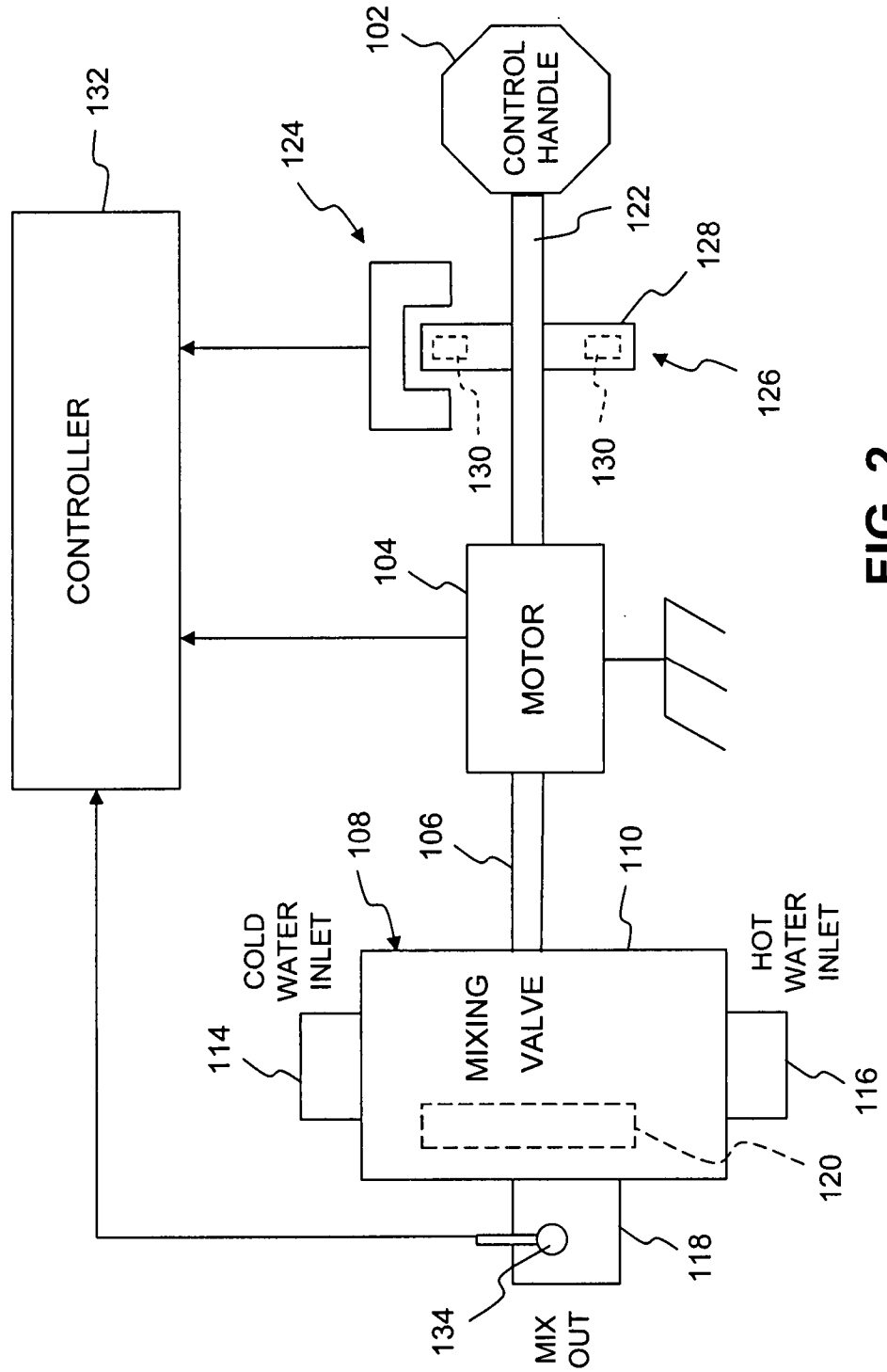
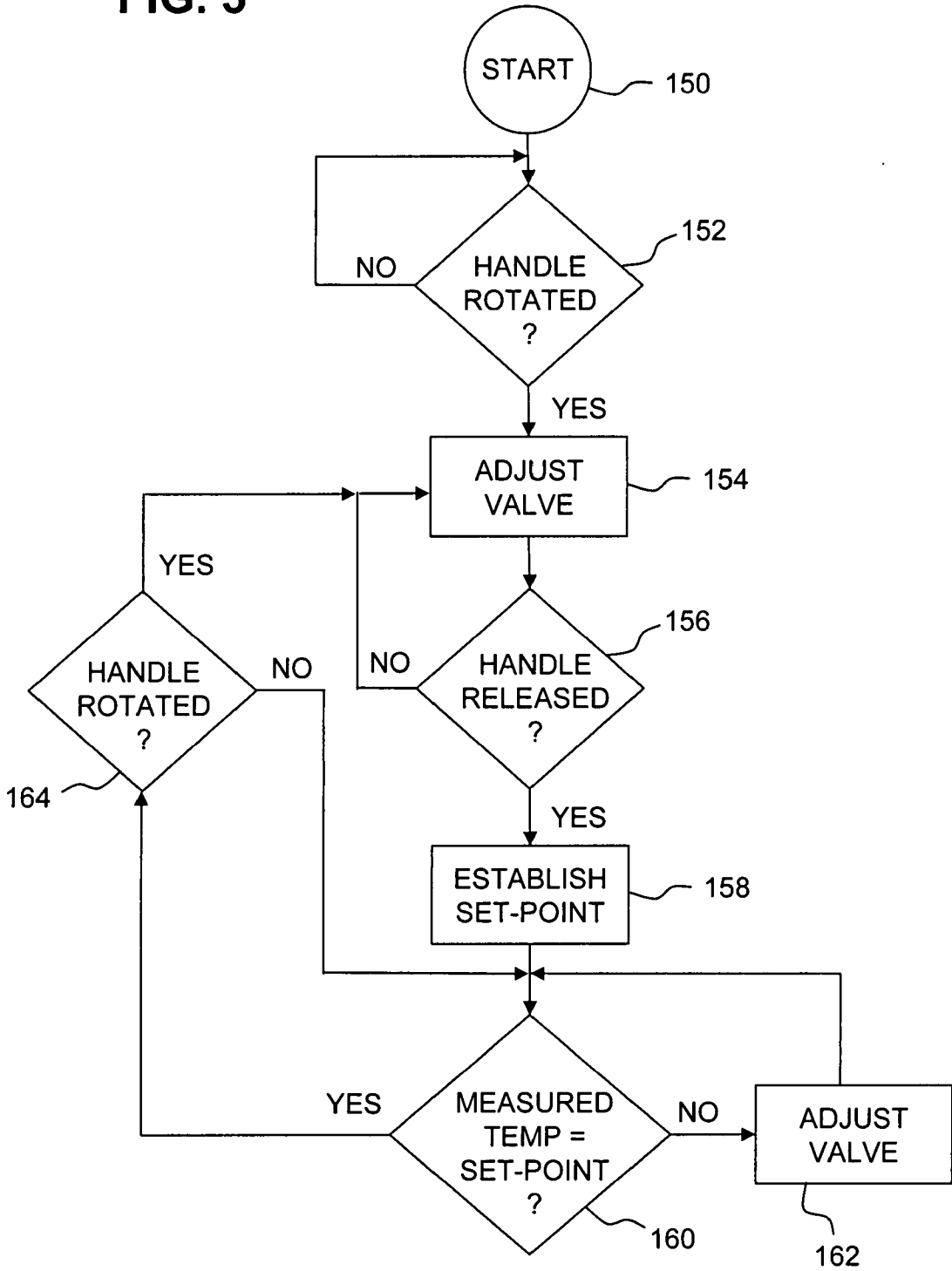


FIG. 2

FIG. 3



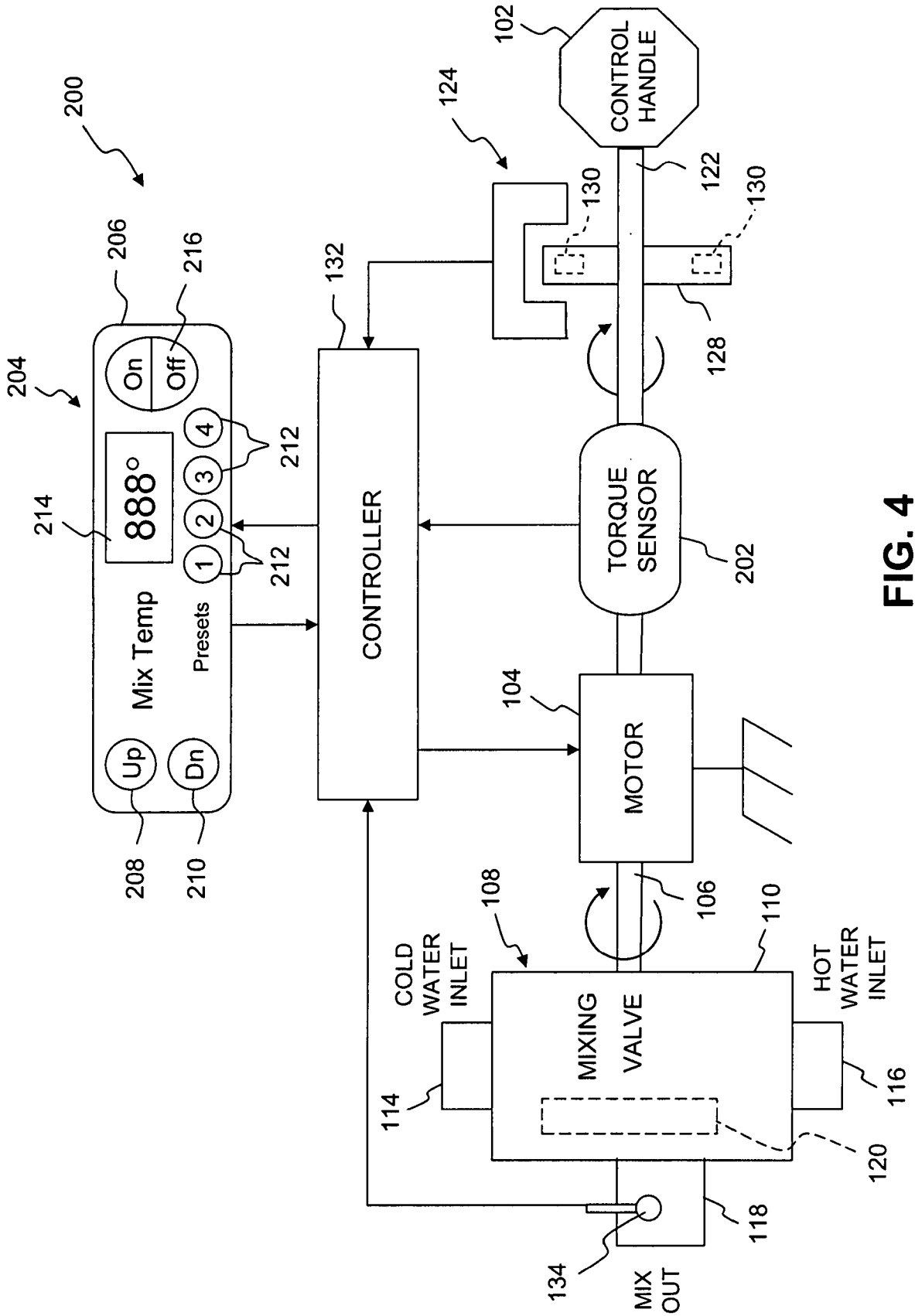


FIG. 4