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Connected pool and spa heater system

Abstract

A connected heating system is provided. The system includes a heater having a first inflow port and a first outflow port, a controller that monitors one or more conditions relating to the heater, and a heater bypass coupled between the first inflow port and the first outflow port. The system also includes a valve that controls flow of water received from a pool into the first inflow port and the heater bypass based on operating state identified by the controller. In operation, responsive to the controller identifying the operating state, the controller is configured to transmit control signals that direct actuation of the valve to achieve the operating state. Additionally, the heater is configured to heat portions of the water from the pool that flow between the first inflow port and the first outflow port when a heating mode is active.

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References Cited**U.S. PATENT DOCUMENTS**

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
4279128	12/1980	Leniger	N/A	N/A
5577661	12/1995	Puett, Jr.	237/63	E04H 4/129
2004/0004034	12/2003	Hornsby	210/167.12	F16K 31/0668
2009/0039030	12/2008	Revak	210/764	C02F 1/02
2013/0291948	12/2012	Mc Queen	137/334	E04H 4/12
2015/0040307	12/2014	Deloche et al.	N/A	N/A
2015/0260428	12/2014	Haldeman	4/493	F24H 1/142
2015/0368921	12/2014	Dzindo	62/238.7	F24H 15/32
2017/0215261	12/2016	Potucek	N/A	G05D 21/02

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
9609500	12/1995	WO	N/A

OTHER PUBLICATIONS

Extended European Search Report issued for European Patent Application No. 22156091.5 dated Jun. 13, 2022, 9 pages. cited by applicant

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Background/Summary

RELATED APPLICATIONS (1) This application claims priority to U.S. Provisional Application No. 63/200,024 filed on Feb. 10, 2021, and titled "CONNECTED POOL AND SPA HEATER

SYSTEM.” U.S. Application No. 63/200,024 is hereby fully incorporated by reference as if set forth fully herein.

BACKGROUND

(1) As the cost of microprocessors and other computing components has decreased, there has been expanded use of such components to create network connected controllable systems for pools and/or spas. However, such existing systems have not fully developed the connectivity with respect to the pool and/or spa water heating systems. In particular, there is an ongoing need for improved connected heating systems that report relevant data to associated control systems via a simple easy to connect interface and data format.

(2) Furthermore, there is a need for improved integration between connected heating systems and valves that control flow of water into and out of the heater. For example, in some pool and spa heating systems, a manually controlled valve is used in relation to a heater bypass to control a flow rate of water entering into the heater. Normally, the user needs to manually adjust this valve based on various environmental and/or seasonal factors to ensure efficient operation of the heater. This manual adjustment is particularly important in systems where the heater comprises a heat pump and maintaining a maximum coefficient of performance (COP) for the heat pump can result in significant energy cost savings. However, the effort associated with monitoring and changing the valve manually has led users to disregard the adjustment process, which has led to inefficient use of the heat pumps.

(3) In light of these and other defects there is continuing need for improved pool and spa heater systems.

Description

DESCRIPTION OF THE DRAWINGS

(1) FIG. 1 is a schematic diagram of a connected pool system according to disclosed embodiments;

(2) FIG. 2 is an isometric view of a connected heater system according to disclosed embodiments that may be used in the pool system depicted in FIG. 1;

(3) FIG. 3 is a schematic drawing of the connected heater system of FIG. 2 according to disclosed embodiments;

(4) FIG. 4 is a schematic cross-sectional view of various internal components of a heater of a connected heater system of FIGS. 2 and 3 according to disclosed embodiments;

(5) FIG. 5 is a schematic cross-sectional view of various internal components of the heater of the connected heater system of FIGS. 2 and 3 according to disclosed embodiments;

(6) FIG. 6A is a front view of a heater of a connected heater system according to disclosed embodiments;

(7) FIG. 6B is a cross-sectional view of a heater of a connected heater system according to disclosed embodiments;

(8) FIG. 7A is a front view of a heater of a connected heater system according to disclosed embodiments;

(9) FIG. 7B is a cross-sectional view of a heater of a connected heater system according to disclosed embodiments;

(10) FIG. 8A is a first partial view of a connection diagram of a connected heater system according to disclosed embodiments;

(11) FIG. 8B is a second partial view of a connection diagram of a connected heater system according to disclosed embodiments;

(12) FIG. 8C is a third partial view of a connection diagram of a connected heater system according to disclosed embodiments;

(13) FIG. 8D is a fourth partial view of a connection diagram of a connected heater system

according to disclosed embodiments;

(14) FIG. 9 is a schematic diagram of a connected pool system according to disclosed embodiments;

(15) FIG. 10 is a schematic view of a connected heater for use in the connected pool system of FIG. 9 according to disclosed embodiments;

(16) FIG. 11 is a schematic cross-sectional view of various internal components of the connected heater of FIG. 10 according to disclosed embodiments;

(17) FIG. 12 is a schematic view of the connected heater of FIG. 10 according to disclosed embodiments;

(18) FIG. 13 is an isometric view of an actuator for a valve for use in the connected heater of FIGS. 10-12 according to disclosed embodiments;

(19) FIG. 14 is an isometric view of an alternative actuator for a valve for use in the connected heater of FIGS. 10-12 according to disclosed embodiments;

(20) FIG. 15 is an isometric view of the actuator of FIG. 13 interfacing with the valve of the connected heater of FIGS. 10-12 according to disclosed embodiments; and

(21) FIG. 16 is an isometric view of the actuator of FIG. 13 interfacing with another valve of the connected heater of FIGS. 10-12 according to disclosed embodiments.

SUMMARY

(22) Embodiments described herein include a connected heating system comprising a heater having a first inflow port and a first outflow port, a controller that monitors one or more conditions relating to the heater, a heater bypass coupled between the first inflow port and the first outflow port, and a valve that controls flow of water received from a pool into the first inflow port and the heater bypass based on operating state identified by the controller. Responsive to the controller identifying the operating state, the controller is configured to transmit control signals that direct actuation of the valve to achieve the operating state. The heater is configured to heat portions of the water from the pool that flow between the first inflow port and the first outflow port when a heating mode is active.

(23) In some embodiments, the heater bypass includes a second inflow port coupled to the first inflow port of the heater and a second outflow port coupled to the first outflow port of the heater. The valve is coupled between the second inflow port and the second outflow port. The operating state includes a timed sequence of actuations of the valve between a closed state and an opened state. In the closed state, the valve blocks flow of the water from the pool between the second inflow port and the second outflow port, and, in the open state, the valve attenuates flow of the water from the pool into the first inflow port by directing the water received from the pool to flow into both the first inflow port of the heater and the second inflow port of the heater bypass.

(24) In some embodiments, the operating state includes one of a plurality of actuation states of the valve. The plurality of actuation states of the valve includes a fully closed state, a fully open state, and one or more intermediate states. In the fully closed state, the valve directs the water received from the pool to flow into the heater bypass by blocking flow into the first inflow port. In the fully open state, the valve enables water to flow freely into the first inflow port by blocking flow into the heater bypass. In the one or more intermediate states, the valve attenuates flow of the water from the pool into the first inflow port by directing the water received from the pool to flow into both the heater bypass and the first inflow port.

(25) In some embodiments, the heater includes a gas heater comprising a heater control board, an ignition control module electrically connected to the heater control board, a burner, and a blower motor. The heater control board is configured to activate the blower motor and direct the ignition control module to ignite the burner to engage the heating mode.

(26) In some embodiments, the heating system further comprises a water temperature sensor electrically coupled to the controller. In these embodiments, the one or more conditions relating to the heater include a temperature of the water flowing between the first inflow port and the first

outflow port as relayed to the controller by the temperature sensor. When the controller determines that the temperature of the water is below a first preconfigured threshold, the heater control board engages the heating mode, and the controller identifies the operating state as a fully open state where the valve enables the water from the pool to flow freely into the first inflow port by blocking flow into the heater bypass. When the controller determines that the temperature of the water is above a second preconfigured threshold, the heater control board disengages the heating mode, and the controller identifies the operating state as an intermediate state where the valve attenuates flow of the water from the pool into the first inflow port by directing the water received from the pool to flow into both the heater bypass and the first inflow port.

(27) In some embodiments, the heater control board comprises the controller. In some embodiments, the controller is electrically connected to the heater control board via a wireless medium. In some embodiments, the controller is electrically connected to the heater control board via an RS485 connection that includes a half-duplex 485 link that operates in a listen only mode such that the heater control board is configured to transmit only when sending of data to the controller is required.

(28) In some embodiments, the heater system further comprises an actuator connected to the valve and electrically coupled to the controller. The actuator is configured to actuate the valve into the operating state in response to receiving the control signals from the controller.

(29) In some embodiments, the valve includes a T configuration where one opening of the valve is coupled to the first inflow port by a pipe or conduit that is substantially parallel to the ground and another opening of the valve is coupled to the heater bypass. In these embodiments, the heater bypass is substantially perpendicular to the ground. In some embodiments, a check valve is positioned between the first outflow port and a second outflow port of the heater bypass to prevent heated water from flowing back into the heater.

(30) In some embodiments, the heater includes a heat pump comprising a heater control board, an expansion valve, a compressor, a condenser coupled between the expansion valve and the compressor, an evaporator coupled between the expansion valve and the compressor, a fan that removes cool air from the heater and directs outside air onto the evaporator, and a thermal fluid configured to circulate through the expansion valve, the compressor, the condenser, and the evaporator. The condenser is in contact with the water flowing between the first inflow port and the first outflow port and the heater control board is configured to activate the fan, the expansion valve, and the compressor to circulate the thermal fluid to engage the heating mode. During circulation, the thermal fluid is initially heated by the outside air that collects on the evaporator, is further heated via compression by the compressor, and sheds heat to the water flowing between the first inflow port and the first outflow port at the condenser.

(31) In some embodiments, the connected heating system further comprises a water temperature sensor electrically coupled to the controller and configured to measure and relay to the controller a temperature of the water flowing between the first inflow port and the first outflow port. When the controller determines that the temperature of the water is below a first preconfigured threshold, the heater control board engages the heating mode, and, when the controller determines that the temperature of the water is above a second preconfigured threshold, the heater control board disengages the heating mode.

(32) In some embodiments, the controller parses the one or more conditions relating to the heater to determine a current coefficient of performance (COP) of the heat pump, and wherein, when the current COP is less than a maximum COP, the controller identifies the operating state for the valve as one where the valve controls the flow of the water received from the pool into the first inflow port and the heater bypass to change the current COP to the maximum COP.

(33) In some embodiments, the connected heating system further comprises a housing that contains the heater control board, the expansion valve, the compressor, the condenser the evaporator, the fan, the valve, and the heater bypass. The heater bypass includes a second inflow port coupled to

the first inflow port of the heater and a second outflow port coupled to the first outflow port of the heater and the valve is coupled between the second inflow port and the second outflow port. The operating state includes a timed sequence of actuations of the valve between a closed state and an opened state. In the closed state, the valve blocks flow of the water from the pool between the second inflow port and the second outflow port. In the open state, the valve attenuates flow of the water from the pool into the first inflow port by directing the water received from the pool to flow into both the first inflow port of the heater and the second inflow port of the heater bypass. The controller identifying the operating state so as adjust the current COP to the maximum COP includes the controller identifying a new timed sequence of actuations of the valve between the closed state and the opened state.

(34) In some embodiments, the one or more conditions include at least one or more of a respective temperature of the water at the first inflow port and the first outflow port, a condensing temperature, and pressure at an outlet of the compressor.

(35) In some embodiments the connected heating system further comprises a plurality of sensors that each correspond to one or more of the one or more conditions monitored by the controller, wherein the plurality of sensor include at least one of a temperature sensor, a pressure sensor, and/or a flow rate monitor.

(36) In some embodiments, the controller is electrically connected to the heater control board via at least one of a wired medium and wireless medium.

(37) Embodiments described herein also include a connected heating system comprising a heater having a housing, a first inflow port in fluid communication with the housing, a first outflow port, a heater control board disposed inside the housing, an ignition control module electrically connected to the heater control board and disposed inside the housing, a burner disposed inside the housing, and a blower motor disposed inside the housing. The connected heating system also comprises a controller that monitors a temperature of water flowing between the inflow port and the outflow port of the heater, a heater bypass coupled between the first inflow port and the first outflow port, and a valve that controls flow of water received from a pool into the first inflow port and the heater bypass based on operating state identified by the controller. Responsive to the controller identifying the operating state, the controller is configured to transmit control signals that direct actuation of the valve to achieve the operating state. The heater is configured to engage a heating mode to heat portions of the water from the pool that flow between the first inflow port and the first outflow port by activating the blower motor and directing the ignition control module to ignite the burner.

(38) In some embodiments, the operating state includes one of a plurality of actuation states of the valve, the plurality of actuation states of the value including a fully closed state, a fully open state, and one or more intermediate states, wherein, in the fully closed state, the valve directs the water received from the pool to flow into the heater bypass by blocking flow into the first inflow port, wherein, in the fully open state, the valve enables water to flow freely into the first inflow port by blocking flow into the heater bypass, and wherein, in the one or more intermediate states, the valve attenuates flow of the water from the pool into the first inflow port by directing the water received from the pool to flow into both the heater bypass and the first inflow port.

(39) In some embodiments, the connected heating system further comprises a water temperature sensor electrically coupled to the controller. The water temperature sensor measures and relays to the controller the temperature of the water flowing between the inflow port and the outflow. When the controller determines that the temperature of the water is below a first preconfigured threshold, the heater control board engages the heating mode, and the controller identifies the operating state as a fully open state where the valve enables the water from the pool to flow freely into the first inflow port by blocking flow into the heater bypass. When the controller determines that the temperature of the water is above a second preconfigured threshold, the heater control board disengages the heating mode, and the controller identifies the operating state as an intermediate state where the valve attenuates flow of the water from the pool into the first inflow port by

directing the water received from the pool to flow into both the heater bypass and the first inflow port.

(40) Embodiments described herein are also directed to a method comprising monitoring a temperature of water flowing between an inflow port and an outflow port of the heater via a controller and a sensor in communication with the controller, engaging a heating mode of the heater to heat the water flowing between the inflow port and the outflow port via a heater control board of the heater when the controller determines that the temperature of the water is below a first preconfigured temperature threshold, sending a first control signal to actuate a valve into a fully open state where the valve enables the water to flow freely into the first inflow port by blocking flow into a heater bypass when the heating mode is engaged, disengaging the heating mode of the heater when the controller determines that the temperature of the water is above a second preconfigured temperature threshold, and sending a second control signal to actuate the valve into an intermediate state where the valve attenuates flow of the water into the inflow port by directing the water to flow into both the heater bypass and the first inflow port when the heating mode is disengaged. In some embodiments of the method, the first preconfigured temperature is the same as the second preconfigured temperature. In some embodiments of the method the controller is electrically connected to the heater control board via an RS485 connection that includes a half-duplex 485 link that operates in a listen only mode such that the heater control board is configured to transmit only when sending of data to the controller is required.

(41) Embodiments described herein are also directed to a method comprising monitoring one or more conditions relating to a heat pump via a controller, parsing, via the controller, the one or more conditions relating to the heat pump to determine a current coefficient of performance (COP) of the heat pump, identifying, with the controller, an operating state for a valve that adjusts the current COP to the maximum COP when the current COP is less than a maximum COP, transmitting control signals that direct actuation of the valve to achieve the operating state from the controller to an actuator for the valve, actuating the valve into the operating state via the actuator in response to receiving the actuator the control signals from the controller, and controlling flow of water received from a pool into a first inflow port of the heat pump and a second inflow port of heater bypass with the valve to adjust the current COP to the maximum COP when the valve is actuated into the operating state.

(42) In some embodiments of the method, the operating state includes a timed sequence of actuations of the valve between a closed state and an opened state. In the closed state, the valve blocks flow of the water from the pool between the second inflow port of the heater bypass and a second outflow port of the heater bypass. In the open state, the valve attenuates flow of the water from the pool into the first inflow port by directing the water received from the pool to flow into both and the first inflow port of the heater and the second inflow port of the heater bypass. The controller identifying the operating state so as adjust the current COP to the maximum COP includes the controller identifying a new timed sequence of actuations of the valve between the closed state and the opened state.

(43) In some embodiments of the method, the one or more conditions include at least one or more of a respective temperature of the water at the first inflow port of the heat pump and a first outflow port of the heat pump, a condensing temperature, and/or a pressure at an outlet of a compressor of the heat pump.

DETAILED DESCRIPTION

(44) Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,”

“comprising,” or “having” and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms “mounted,” “connected,” “supported,” and “coupled” and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings.

(45) The following discussion is presented to enable a person skilled in the art to make and use embodiments of the invention. Various modifications to the illustrated embodiments will be readily apparent to those skilled in the art, and the generic principles herein can be applied to other embodiments and applications without departing from embodiments of the invention. Thus, embodiments of the invention are not intended to be limited to embodiments shown but are to be accorded the widest scope consistent with the principles and features disclosed herein. The following detailed description is to be read with reference to the figures, in which like elements in different figures have like reference numerals. The figures, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of embodiments of the invention. Skilled artisans will recognize the examples provided herein have many useful alternatives and fall within the scope of embodiments of the invention.

(46) FIG. 1 illustrates an exemplary connected aquatic application, such as a pool or spa system **20**, according to disclosed embodiments. As seen in FIG. 1, the connected pool or spa system **20** can include a heating system **22** configured to heat water for the pool and/or a spa to a set temperature. One or more additional components may be optionally included in the pool or spa system **20**, including, for example, a filter, a booster pump, a variable speed pump, one or more sensors and/or valves, a pH and/or water chemistry regulation mechanism, a water quality monitor, a sanitizer, and various communication enabling devices, described in more detail below. One or more of the components are provided in communication with each other and the pool to form a fluid circuit. The fluid circuit facilitates water movement from the pool or spa through one or more of the pool components and the fluid circuit to accomplish various tasks including, for example, pumping, cleaning, heating, sanitizing, and the like. Additional arrangements of the one or more additional components besides those shown in FIG. 1 that are known in the art are also contemplated.

(47) Still referring to FIG. 1, the pool or spa system **20** further includes a central controller **24**, and a portable user device **26** that can interface with the central controller **24**, either directly over a local area network, or via a cloud network **28**. Although FIG. 1 depicts the central controller **24**, the portable user device **26**, and the cloud network **28**, it should be noted that various communication methodologies and connections may be implemented to work in conjunction with, or independent from, one or more local controllers associated with each individual components associated with the pool or spa system **20** (e.g., controller of the pump, controller of the heater, etc.).

(48) As best seen in FIGS. 1 and 2, the heating system **22** is provided in the form of a heater **30**, a heater control board **32**, and a valve **34** that is configured to control flow of water into and out of the heater **30**.

(49) The heater **30** includes a housing **31** in fluid communication with a first inflow port **33** and a first outflow port **35** designed to accommodate incoming and outgoing water, respectively, through the heater **30**. Plumbing is provided to facilitate fluid communication between the various components of the heating system **22**. The heater bypass **23** can be coupled between the first inflow port **33** and the first outflow port **35** and can include a second inflow port **25** and a second outflow port **27**. In some embodiments, the heating system **22** can include a check valve **36** provided in the plumbing of the first outflow port **35** of the heater **30** that is designed to prevent heated water from flowing back into the heater **30**.

(50) In operation, a controller such as the heater control board **32**, the central controller **24**, and/or the portable user device **26**, can monitor one or more conditions relating to the heater **30**. The valve **34** can be configured to control flow of water received from a pool into the first inflow port **33** and

the heater bypass **23** based on operating state identified by the controller, and the heater **30** can be configured to heat portions of the water from the pool that flow between the first inflow port **33** and the first outflow port **35** when a heating mode is active. Furthermore, in response to identifying the operating state, the controller can be configured to transmit control signals that direct actuation of the valve **34** to achieve the operating state. In some embodiments, the controller can be electrically coupled to a plurality of sensors **39** that relay the one or more conditions relating to the heater **30** to the controller.

(51) Referring to FIG. 2 and FIG. 3, in some embodiments, the valve **34**, can be provided as a three way valve with various open and closed positions, as described hereinbelow. The valve **34** can be coupled to the first inflow port **33** of the heater **30** and, in embodiments where the controller comprises the heater control board **32**, can be electrically connected to the heater control board **32** to receive control commands therefrom to change a position of the valve **34**. In some embodiments, the valve **34** may be the Intellivalve™ provided by Pentair Water Pool & Spa (Cary, NC).

Furthermore, as seen in FIG. 2, in some embodiments, the valve **34** can be placed outside of the housing **31** and have a T configuration where one opening of the valve **34** is coupled to the first inflow port **33** by a pipe or conduit that is substantially parallel to the ground, and another opening of the valve **34** is coupled to the heater bypass **23** that is substantially perpendicular to the ground. Further still, as seen in FIG. 2 the check valve **36** can be positioned between the first outflow port **35** and the second outflow port **27**. In some embodiments, another pipe or conduit between an exit port of the check valve **36** and the second outflow port **27** can have an s-shape configuration where one end is higher of the ground than another end. It should be noted that other additional positions and configurations for the pipes or conduits as known in the art are also contemplated.

(52) In some embodiments, the operating state for the valve **34** can include one of a plurality of actuation states of the valve **34**. These plurality of actuation states can include a fully closed state, a fully open state, and one or more intermediate states. In the fully closed state, the valve **34** directs the water received from the pool to flow into the heater bypass **23** by blocking flow into the first inflow port **33**. In the fully open state, the valve **34** enables water to flow freely into the first inflow port **33** by blocking flow into the heater bypass **23**. In the one or more intermediate states, the valve **34** can attenuate flow of the water from the pool into the first inflow port **33** by directing the water received from the pool to flow into both the heater bypass **23** and the first inflow port **33**.

(53) As shown in FIG. 4, in some embodiments the heater **30** can include a gas heater that further includes an ignition control board or module **38**, a blower motor **40**, an exhaust **41**, an air/fuel mixing chamber **42**, a burner **44**, heating coils **46** through which the water fed into the heater **30** flows, and one or more other components associated with a gas heater. The ignition control module **38** is coupled to and controlled by the heater control board **32**. For example, the heater control board **32** is configured to activate the blower motor **40** and direct the ignition control module **38** to ignite the burner **44** to engage the heating mode.

(54) Furthermore, as seen in FIGS. 5-7B, various embodiments for the size and shape of the heater **30** are contemplated so as to accommodate different water heating requirements as would be understood by those having ordinary skill in the art. For example, as seen in FIG. 5, the heater **30** can have a large internal volume section for accommodating a larger volume of water flow. However, as seen in FIG. 6A and FIG. 6B, a compact lower internal volume heater is also contemplated. Further still, as seen in FIGS. 7A and 7B, a version of the heater **30** where the housing **31** has a rounded profile is contemplated. Furthermore, as seen in FIGS. 5-7B various orientations for the first inflow port **33** and the first outflow port **35** are contemplated. For example, as seen in FIGS. 5, 7A, and 7B, the first inflow port **33** and the first outflow port **35** can be arranged in a vertical configuration with the first inflow port **33** on top of the first outflow port **35**. Additionally or alternatively, as seen in FIGS. 6A and 6B, the first inflow port **33** and the first outflow port **35** can be arranged in a horizontal configuration where the first inflow port **33** is on a left side of the housing **31** and the first outflow port is on a right side of the housing **31**. Additional

and alternative arrangements known in the art are also contemplated including arrangements where the positions of the first inflow port **33** and the first outflow port **35** are swapped.

(55) In some embodiments, the controller, including but not limited to the heater control board **32**, can engage the heating mode and control actuation of the valve **34** based on a temperature of the water flowing between the first inflow port **33** and the first outflow port **35**. In these embodiments, one of the plurality of sensors **39** can include a water temperature sensor (e.g. a thermistor) and the one or more conditions relating to the heater **30** can include the temperature of the water flowing between the first inflow port **33** and the first outflow port **35** as relayed to the controller by the temperature sensor. In these embodiments, when the controller determines that the temperature of the water is below a first preconfigured threshold, the heater control board **32** can engage the heating mode and the controller can identify the operating state for the valve **34** as a fully open state where the valve **34** enables the water from the pool to flow freely into the first inflow port **33** by blocking flow into the heater bypass **23**. Furthermore, when the controller determines that the temperature of the water is above a second preconfigured threshold the heater control board **32** can disengage the heating mode and the controller can identify the operating state as an intermediate state where the valve **34** attenuates flow of the water from the pool into the first inflow by directing the water received from the pool to flow into both the heater bypass **23** and the first inflow port **33**. In some embodiments, the first preconfigured threshold can be the same as the second preconfigured threshold. However, in some embodiments the first preconfigured threshold can be lower than the second preconfigured threshold.

(56) The heater control board **32** is also designed to undertake various other control operations of the heater **30**. For example, a user may manually turn the heater **30** on by pushing a button (not shown) on the heater **30**, or via an interface provided on the portable user device **26**. Alternatively, a user may enter the first or second preconfigured thresholds or other desired water temperature setpoints, or water temperature setpoint ranges (e.g., upper and lower limit) in which the heater **30** should maintain the water temperature at. In other embodiments, the user may set a schedule in which the heater **30** should operate.

(57) In one example of the operation process described herein, the heater control board **32** may use inputs from one or more of the plurality of sensors **39**, internally stored settings, and/or control signals received from other devices (e.g., local on-board controllers, the central controller **24**, and/or the portable user device **26**) to commence various operations. Based on the inputs, the heater control board **32** is designed to direct (1) the ignition control module **38** to activate the blower motor **40** so as to begin mixing air and fuel together in the mixing chamber **42**, and feed the mix of air and fuel to the burner **44**, (2) the ignition control module **38** to ignite the burner **44** to combust the mix of air and fuel so that water flowing through the heating coils **46** is heated to the desired temperature, and (3) control operation of the valve **34** to one of the plurality of actuation states where approximately 100% of the water flowing into the valve **34** flows into the heater **30** and through the heating coils **46**. In some embodiments, during a normal heating operation, the one of the plurality of operating states for the valve **34** may be an opened state where a small amount of water (e.g., less than 5%) is bypassed around the heater **30** through the heater bypass **23**.

(58) In some embodiments, once the heater control board **32** determines that the water has been sufficiently heated and has reached a pre-determined temperature setpoint, the heater control board **32** is designed to direct (1) the ignition control module **38** to deactivate the burner **44** and the blower motor **40**, and (2) the valve **34** to transition to a second one of the plurality of operating states where the valve **34** is operated between about 90% to about 95% to allow less than 100% of the water flowing into the valve **34** to flow into the heater **30**. In some embodiments, when in the second one of the plurality of operating, the valve **34** can allow between about 5% to about 10% of the water flowing into the valve **34** to flow into the heater **30**.

(59) Allowing water to flow into the heater **30** when the heater **30** is not actively heating permits measurement of the temperature of the water irrespective of the state of the valve **34**. Further,

directing a small water flow through the heater **30** during this operation also can reduce the resistance in the system and decrease an amount of wear and tear on a heat exchanger of the heater **30**. For example, in some embodiments, when the heater **30** is bypassed, an internal heat exchanger can be exposed to a lower flow rate and a reduced overall volume of water having certain corrosive properties. This can extend the service life of the heat exchanger because the heater **30** can be subjected to a less-corrosive environment during the periods in which the heat exchanger is being bypassed. The bypass operation can also include other benefits. For example, in some embodiments, when the heater **30** is being bypassed, a speed of a variable flow pump's motor that pumps water to the heater **30** can be reduced because a total dynamic head of the system will be lower than it is when the heater is not being bypassed. This speed reduction can reduce the electrical usage of the variable speed pump and result in energy bill cost savings for the user.

(60) In some embodiments, the percentages that the valve **34** is opened or closed in the various ones of the plurality of operating states can be set by a user either locally on the heater **30** or via the portable user device **26** through the central controller **24**. For example, in some embodiments, the portable user device **26** can receive user input setting the open/close percentages which the central controller **24** can relay to the heater control board **32** for storage in a local memory thereof.

(61) FIGS. **8A-D** are partial views of a connection diagram for the heating system **22** according to disclosed embodiments. In some embodiments, the heater control board **32** can be coupled to various sensors and switches **48** that monitor for and/or activate at the presence of different potential error or fault conditions for the heater **30** and can include a data connection **50** for coupling the heater control board **32** to the valve **34**. In some embodiments, the heater control board **32** can be connected to the central controller **24** using an RS485 connection **49** and can communicate control signals, outputs from the various sensors and switches **48**, and other relevant data using a customized protocol.

(62) Furthermore, in some embodiments, the RS485 connection **49** can include a half-duplex 485 link that operates in a listen only mode. In some embodiments, the listen only mode can include the heater control board **32** being configured to transmit only when sending of data to the central controller **24** is required. In some embodiments, the heater control board **32** can be configured only to transmit in response to a command from the central controller **24**. In some embodiments, the heater control board **32** can ensure data integrity prior to use of the data, by using one or more of a proper address, a proper opcode, a proper packet length, and a proper checksum when compiling and transmitting data to the central controller **24**.

(63) In some embodiments, the central controller **24** can be configured as the system master and also operate in a listen only mode (e.g. transmitting only when required). In these embodiments, the central controller **24** can send continuous 'heartbeat' or 'keep alive' packets to the heater control board **32** at a preconfigured rate, such as, for example, approximately every 2 seconds. The continuous 'heartbeat' or 'keep alive' packets can be sent as an undependable transmission where no response from the heater control board **32** is expected or required. In some embodiments, the heater control board **32** can be configured to revert to a standalone or default operation when the continuous 'heartbeat' or 'keep alive' packets fail to be received for more than a preconfigured amount of time (e.g. 60 seconds). In some embodiments, the continuous 'heartbeat' or 'keep alive' packets can be assigned a global destination address when sent to enable the continuous 'heartbeat' or 'keep alive' packets to be received by the heater control board **32** and any other heater control boards in the connected pool or spa system **20**.

(64) In some embodiments, the RS485 connection **52** can include color coded **4** wire terminals. For example, in some embodiments, the **4** wire terminals can be color coded with black indicating a DC/Signal Ground, green indicating RS485 'B'/'-Data', Yellow indicating RS485 'A'/' +Data', and Red indicating +15 VDC.

(65) In some embodiments, a command packet from the central controller **24** to the heater control board **32** can include a first preconfigured value associated with the central controller **24** as the

source address, a second preconfigured value associated with the heater control board **32** as the destination address, and various control commands for the heater control board **32** in the info field. In some embodiments, the second preconfigured value can be set via user input on a front panel of the heater **30** and/or remotely via the portable user device **26**. In some embodiments, the various control commands can include one or more of (1) a System On/Off byte configured to switch the heater **30** between a first mode where the heater is deactivated, a second mode where the heater **30** is activated to heat a pool, and/or a third mode where the heater **30** is activated to heat a spa, (2) a Pool Water Heat Set Point byte that sets a specific water temperature (e.g. between 42-104° F.) for heating in the second mode, (3) a Spa Water Heat Set Point byte that sets a specific water temperature (e.g. between 42-104° F.) for heating in the third mode, and (4) a service mode byte that can switch operation of the heater controller board **32** between remote control, local control, or standalone mode.

(66) In some embodiments, a response packet from the heater control board **32** to the central controller **24** can include the second preconfigured value as the source address, the first preconfigured value as the destination address, and operation data about the heater control board **32** in the info field. In some embodiments, the operation data can include one or more of (1) a heater model ID byte that identifies a model number of the heater **30**, (2) a heater mode byte that identifies whether the heater is in the first, second, or third mode, (3) a heating status byte that identifies whether the burner **44** is currently firing or not, and (4) an error mode byte that can include error information pertaining to the potential error or fault conditions for the heater **30** sent as error codes using 8 individual bit flags. In some embodiments, a value of 0 can be used to indicate NO ERROR. In some embodiments, spare bytes of the packet can be assigned to additional error codes when more than 8 error codes are needed.

(67) As seen in FIGS. **8A-D**, in some embodiments, the various sensors can include one or more of an automatic fuel shutoff switch that stops fuel from flowing into the mixing chamber **42** when a temperature of the water leaving the heater **30** is above a preconfigured threshold (e.g. greater than 140° F.), a high limit switch that activates when a temperature of the water entering the heater **30** is above a preconfigured threshold (e.g. greater than 135° F.), a pressure switch that activates when there is no flow into the heater **30**, an air flow switch that activates when there is not a differential pressure across an air orifice to indicate that the blower motor **40** is not operating correctly, a thermistor that monitors a temperature of the water flowing in the heater **30**, and a stack flue sensor (SFS) that monitors a temperature of exhaust gas from the heater **30**. In some embodiments, the error codes for the customized protocol can represent different outputs from the various sensors and switches **48**. For example, in some embodiments the error codes can include (1) an indication that automatic fuel shutoff switch has activated, (2) an indication that the high limit switch has activated, (3) an indication that the pressure switch has activated, (4) an indication that the air flow switch has activated, (4) a thermistor open signal that indicates that thermistor or wiring thereof may be open circuited, (5) a thermistor short signal that indicates that thermistor or wiring thereof may be short circuited, (6) an indication that a value of the SFS has exceeded a preconfigured temperature value (e.g. 450° F.), (7) an SFS open signal that indicates that SFS or wiring thereof may be open circuited, (8) an SFS short signal that indicates that SFS or wiring thereof may be short circuited, and (9) and RS485 Connection Loss indicator.

(68) In some embodiments, the ignition control module **38** can include a flame sense mechanism that outputs a voltage across two pins that can be between 0 and 1 VDC. In these embodiments, the closer the value is to 1 VDC, the stronger the flame. As seen in FIG. **8B**, the heater control board **32** can include a connection **51** to the flame sense output pins of the ignition control module **38**. The connection **51** can include a relay that connects the two pins to the microcontroller for reading and processing. In some embodiments, the heater control board **32** can, via the RS485 connection **49** to the central controller **24**, provide feedback to the user on whether or not the flame sense value is within an acceptable range or an unacceptable range indicative of a possible fuel or air supply

issue. After reading, the voltage the relay can be turned off so as to disconnect the pins for a preset amount of time between readings.

(69) FIG. 9 illustrates another exemplary embodiment of the pool or spa system 20, according to disclosed embodiments. As seen in FIG. 9, the connected pool or spa system 20 can include a heater 52 in place of the heating system 22 that is also configured to heat water for the pool and/or a spa to a set temperature. Furthermore, as seen in FIG. 9 the one or more additional components in the pool or spa system 20, including, for example, the filter, the booster pump, the variable speed pump, the one or more sensors and/or valves, the pH and/or water chemistry regulation mechanism, the water quality monitor, the sanitizer, and the various communication enabling devices, described in more detail below can be arranged in a different configuration from that of FIG. 1. In particular, as seen in FIG. 9 the booster pump is positioned after the filter and the water quality monitor is positioned after the filter, before the heater 52, and before the booster pump. However, further arrangements of the one or more additional components in the pool or spa system 20 as would be known to those of ordinary skill in the art are also contemplated. As described above in connecting with FIG. 1 the one or more of the components are provided in communication with each other and the pool to form a fluid circuit and/or filtration system. The fluid circuit facilitates water movement from the pool or spa through one or more of the pool components and the fluid circuit to accomplish various tasks including, for example, pumping, cleaning, heating, sanitizing, and the like.

(70) As seen in FIGS. 9 and 10, the heater 52 can include a housing 53 in which a heater bypass 58, a condenser 60, a heater control board 56, and a valve 54 are provided. The heater 52 includes a first inflow port 62 and a first outflow port 64 from the condenser 60 that are designed to accommodate incoming and outgoing water, respectively, through the condenser 60. Plumbing is provided to facilitate fluid communication between the various components of the heater 52 as would be understood by those having ordinary skill in the art. The heater bypass 58 can be coupled between the first inflow port 62 and the first outflow port 64 and can include a second inflow port 66 and a second outflow port 68. In some embodiments, the second inflow port 66 can be coupled to the first inflow port 62 and the second outflow port 68 can be coupled to the first outflow port 64 inside the housing 53 as seen in FIG. 10. However, in some embodiments, the valve 54 and/or the heater bypass 58 can be provided outside of the housing 53.

(71) Similar to the heating system 22 described herein, in operation, the controller (e.g. the heater control board 56, the central controller 24, and/or the portable user device 26), can monitor one or more conditions relating to the heater 52. The valve 54 can be configured to control flow of water received from a pool into the first inflow port 62 and the heater bypass 58 based on operating state identified by the controller, and the heater 52 can be configured to heat portions of the water from the pool that flow between the first inflow port 62 and the first outflow port 64 when a heating mode is active. Furthermore, in response to identifying the operating state, the controller can be configured to transmit control signals that direct actuation of the valve 54 to achieve the operating state. In some embodiments, the controller can be electrically coupled to a plurality of sensors 55 (see FIG. 12) that relay the one or more conditions relating to the heater 52 to the controller.

(72) Referring now to FIG. 10, in some embodiments, the valve 54, can be provided as a 2 way valve with various open and closed positions, as described hereinbelow. The valve 54 can be coupled between the second inflow port 66 and the second outflow port 68 and, in embodiments where the controller comprises the heater control board 56, can be electrically connected to the heater control board 56 to receive control commands therefrom to change a position of the valve 54. In some embodiments, the operating state for the valve 54 can include a timed sequence of actuations of the valve 54 between a closed state and an opened state, wherein, in the closed state, the valve blocks flow of the water from the pool between the second inflow port 66 and the second outflow port 68, and wherein, in the open state, the valve attenuates flow of the water from the pool into the first inflow port 62 by directing the water received from the pool to flow into both and the

first inflow port **62** and the second inflow port **66**.

(73) In some embodiments, the heater **52** can include a heat pump. FIG. **11** is a partial cross-sectional view and FIG. **12** is a schematic view of various internal components of a heat pump embodiment of the heater **52** according to disclosed embodiments. As seen in FIGS. **11** and **12**, in these embodiments, the heater **52** can include the heater control board **56**, an expansion valve **74**, a compressor **72**, the condenser **60** coupled between the expansion valve **74** and the compressor **72**, an evaporator **76** coupled between the expansion valve **74** and the compressor **72**, a fan **70** that removes cool air from the heater and directs outside air onto the evaporator **76**, and a thermal fluid configured to circulate through the expansion valve **74**, the compressor **72**, the condenser **60**, and the evaporator **76** in a path indicate by arrow A.

(74) The condenser **60** is in contact with the water flowing between the first inflow port **62** and the first outflow port **64** to transfer heat between the circulating thermal fluid and the water.

Furthermore, the heater control board **56** can be configured to activate the fan **70**, the expansion valve **74**, and the compressor **72** to circulate the thermal fluid to engage the heating mode. During such circulation, the thermal fluid is initially heated by the outside air that collects on the evaporator **76**, is further heated via compression by the compressor **72**, and sheds heat to the water flowing between the first inflow port **62** and the first outflow port **64** at the condenser **60**. In some embodiments, the thermal fluid is heated from a liquid state into a gaseous state before entering the compressor **72** and cooled back into the liquid state when shedding heat to the water flowing between the first inflow port **62** and the first outflow port **64**. Various embodiments for the thermal fluid are contemplated such as refrigerant fluids like R22, R32, R407, R410, and other similar fluids known in the art.

(75) In some embodiments, the controller, including but not limited to the heater control board **56**, can engage the heating mode based on a temperature of the water flowing between the first inflow port **62** and the first outflow port **64**. In these embodiments, one of the plurality of sensors **55** can include a water temperature sensor (e.g. a thermistor) configured to measure and relay to the controller a temperature of the water flowing between the first inflow port **62** and the first outflow port **64**. In these embodiments, when the controller determines that the temperature of the water is below a first preconfigured threshold, the heater control board **56** can engage the heating mode. Furthermore, when the controller determines that the temperature of the water is above a second preconfigured threshold, the heater control board **56** can disengage the heating mode. In some embodiments, the first preconfigured threshold can be the same as the second preconfigured threshold. However, in some embodiments the first preconfigured threshold can be lower than the second preconfigured threshold.

(76) In some embodiments, the controller, including but not limited to the heater control board **56**, can control actuation of the valve **54** to mediate flow of water through the condenser **60** such that a COP of the heater **52** is maximized. In these embodiments, the controller parses the one or more conditions relating to the heater **52** to determine a current COP of the heater **52**. When the current COP is less than a maximum COP, the controller identifies the operating state for the valve **54** as one where the valve **54** controls the flow of the water received from the pool into the first inflow port **62** and the heater bypass **58** to change the current COP to the maximum COP. For example, in embodiments where the valve **54** is the two-way valve that controls the flow rate through the condenser **60** via the timed sequence of actuations between the open and the closed states, the operating state of the valve **54** identified by the controller can include new timed sequence of actuations (e.g. holding the valve **54** open or closed for a longer or shorter time) of the valve **54** between the closed state and the opened state so as adjust the current COP of the heater **52** to the maximum COP. In some embodiments the controller can dynamically adjust the timing of the opening and closing of the valve **54** to achieve the maximum COP for the heater **52**. For example, the controller can continue to adjust the timing of the opening and closing of the valve **54** until the controller determines that the COP for the heater **52** is at the maximum as indicated by the one or

more conditions of the heater **52**. In some embodiments, the controller can be configured to wait a preconfigured time after changing the timing of the opening and closing of the valve **54** before continuing to monitor the one or more conditions of the heater **52** and adjusting the timing so as to achieve the maximum COP. Waiting the preconfigured time can enable the one or more conditions of the heater **52** to balance or stabilize in response to the changed timing.

(77) Various embodiments for the monitoring and calculating the current COP of the heater **52** are contemplated. For example, in some embodiments, the one or more conditions monitored by the controller can include at least one of temperature of the water at the first inflow port **62**, temperature of the water at the first outflow port **64**, a condensing temperature, and pressure of the thermal fluid at an outlet of the compressor **72**. Additionally, in some embodiments, the one or more conditions monitored by the controller can include environmental conditions, external temperature, seasonal information, geographic information, and/or a flow rate of water through the pool or spa system **20** as directed by some of the one or more additional components. For example, in some embodiments, the one or more additional components can include one or more variable speed pumps that alter the flow rate of the water to enable low speed filtering and a high speed skimming period where debris is evacuated on the surface of the pool. Additionally, the flow rate of the water can change based on clogging of a filter and execution of a backwash cycle to unclog the filter. In some embodiments, a preferred flow rate in the condenser **60** to achieve a maximum COP for the heater **52** is approximately 4 to 6 m³/h when the flow rate in the connected pool or spa system **20** is approximately 10 to 18 m³/h.

(78) In some embodiments, each of the plurality of sensors **55** can correspond to one or more of the one or more conditions monitored by the controller. For example, the plurality of sensors **55** can include various temperature sensors positioned throughout the connected pool or spa system **20** including, for example, at the first inflow port **62** and the first outflow port **64**, various pressure sensors, various flow rate monitors, and other sensors as would be understood by those in the art.

(79) FIG. **13** is an isometric view of actuator **78A** for the valve **54**. As seen in FIG. **13**, the actuator **78A** can include a power and data connector **80A** that electrically couples the actuator **78A** to the controller and or a valve control board **82** (see FIG. **12**). The actuator **78A** can be configured to receive control signals from the controller via the power and data connector **80A** and responsive thereto actuate the valve **54** into the operating states as described herein. In some embodiments the actuator **78A** can include the valve actuator for the Intellivalve™ provided by Pentair Water Pool & Spa (Cary, NC). In some embodiments, the actuator **78A** can include approximately 24 defined positions into which the valve **54** can be actuated. Furthermore, in some embodiments, the power and data connector **80A** can include a RS485 Modbus.

(80) FIG. **14** is an isometric view of another actuator **78B** for the valve **54** according to disclosed embodiments. Similar to the actuator **78A**, the actuator **78B** can include a power and data connector **80B** that electrically couples the actuator **78B** to the controller and or the valve control board **82** (see FIG. **12**). The actuator **78B** can be configured to receive control signals from the controller via the power and data connector **80B** and responsive thereto actuate the valve **54** into the operating states as described herein. In some embodiments, control of the valve **54** can be accomplished by controlling a supply time of electric power to actuator **78B**.

(81) In some embodiments, the valve **54** or the actuator **78A** or **78B** can be supplied as a retrofit kit for the heater **52**. Further still, in some embodiments valve control board **82** can be embedded in the actuator **78A** or **78B** or housed externally and electrically coupled thereto as shown in FIG. **12**. In some embodiments, the valve control board **82**, either separately or in conjunction with the heater control board **56**, the central controller **24**, and/or the portable user device **26**, can comprise the controller as described herein.

(82) Various embodiments for interfacing the actuators **78A** and **78B** with the valve **54** are contemplated. For example, as seen in FIG. **15**, in embodiments where the valve **54** includes a two-way valve **84**, the actuator **78A** can be secured to the valve **54** by fasteners **86** such that it interfaces

with a two-way spline **86** of the valve **54** that is maneuvered by the actuator **78A** to position the valve **54** in the operating states as described herein. Similarly, as seen in FIG. **16**, in embodiments where the valve **54** includes a three-way valve **88**, the actuator **78A** can be secured to the valve **54** by fasteners **86** such that it interfaces with a three-way spline **90** of the valve **54** that is maneuvered by the actuator **78A** to position the valve **54** in the operating states as described herein. It will be appreciated, that similar interfacing operations as described and shown for the actuator **78A** are contemplated with respect to the actuator **78B**. Furthermore, it should also be appreciated that the actuators **78A** and **78B**, the two-way valve **84**, and the three-way valve **88** shown in FIGS. **13-16** can be used in relation to the connected heating system **22** and the valve **34** as shown in FIGS. **1-3**.

(83) In some embodiments, the heater control board **56** and/or the valve control board **82** can be coupled to various sensors and switches that monitor for and/or activate at the presence of different potential error or fault conditions for the heater **52** and can include a data connection for coupling the valve control board **82** to the valve **54**. In some embodiments, the valve control board **82** can be connected to the central controller **24** using an RS485 connection such as described here or the like and can communicate control signals, outputs from the various sensors and switches, and other relevant data using a customized protocol as described herein. In some embodiments, the valve control board **82** can be configured only to transmit in response to a command from the central controller **24**. In some embodiments, the valve control board **82** can ensure data integrity prior to use of the data, by using one or more of a proper address, a proper opcode, a proper packet length, and a proper checksum when compiling and transmitting data to the central controller **24**.

(84) It is to be understood that the controller (e.g., the heater control boards **32** and **52**, the central controller **24**, and/or the portable user device **26**) and other connected devices and sensors as disclosed herein can include respective transceiver and memory devices, each of which can be in communication with control circuitry, one or more programmable processors, and executable control software as would be understood by one of ordinary skill in the art. In some embodiments, the control software can be stored on a transitory or non-transitory computer readable medium, including, but not limited to local computer memory, RAM, optical storage media, magnetic storage media, flash memory, and the like, and some or all of the control circuitry, the programmable processors, and the control software can execute and control at least some of the methods described herein.

(85) It will be appreciated by those skilled in the art that while the invention has been described above in connection with particular embodiments and examples, the invention is not necessarily so limited, and that numerous other embodiments, examples, uses, modifications and departures from the embodiments, examples and uses are intended to be encompassed by the claims attached hereto. The entire disclosure of each patent and publication cited herein is incorporated by reference, as if each such patent or publication were individually incorporated by reference herein. Various features and advantages of the invention are set forth in the following claims.

Claims

1. A connected heating system for an aquatic application, comprising: a heater having a first inflow port and a first outflow port; a controller that monitors one or more conditions relating to the heater; a heater bypass coupled between the first inflow port and the first outflow port; and a valve that controls flow of water received from the aquatic application into the first inflow port and the heater bypass based on an operating state identified by the controller, wherein, responsive to the controller identifying the operating state, the controller is configured to transmit control signals that direct actuation of the valve to achieve the operating state, and wherein the heater is configured to heat portions of the water from the aquatic application that flow between the first inflow port and the first outflow port when a heating mode is active.
2. The connected heating system of claim 1, wherein the heater bypass includes a second inflow

port coupled to the first inflow port of the heater and a second outflow port coupled to the first outflow port of the heater, wherein the valve is coupled between the second inflow port and the second outflow port and wherein the operating state includes a timed sequence of actuations of the valve between a closed state and an open state, and in the closed state, the valve blocks flow of the water from the aquatic application between the second inflow port and the second outflow port, and in the open state, the valve attenuates flow of the water from the pool into the first inflow port by directing the water received from the aquatic application to flow into both the first inflow port of the heater and the second inflow port of the heater bypass.

3. The connected heating system of claim 1, wherein the operating state includes one of a plurality of actuation states of the valve, the plurality of actuation states of the valve including a fully closed state, a fully open state, and one or more intermediate states, wherein, in the fully closed state, the valve directs the water received from the aquatic application to flow into the heater bypass by blocking flow into the first inflow port, wherein, in the fully open state, the valve enables water to flow freely into the first inflow port by blocking flow into the heater bypass, and wherein, in the one or more intermediate states, the valve attenuates flow of the water from the aquatic application into the first inflow port by directing the water received from the aquatic application to flow into both the heater bypass and the first inflow port.

4. The connected heating system of claim 1, wherein the heater includes a gas heater comprising a heater control board, an ignition control module electrically connected to the heater control board, a burner, and a blower motor, wherein the heater control board is configured to activate the blower motor and direct the ignition control module to ignite the burner to engage the heating mode.

5. The connected heating system of claim 4 further comprising a water temperature sensor electrically coupled to the controller, wherein the one or more conditions relating to the heater include a temperature of the water flowing between the first inflow port and the first outflow port as relayed to the controller by the temperature sensor, wherein, when the controller determines that the temperature of the water is below a first preconfigured threshold, the heater control board engages the heating mode and the controller identifies the operating state as a fully open state where the valve enables the water from the aquatic application to flow freely into the first inflow port by blocking flow into the heater bypass, and wherein when the controller determines that the temperature of the water is above a second preconfigured threshold the heater control board disengages the heating mode and the controller identifies the operating state as an intermediate state where the valve attenuates flow of the water from the aquatic application into the first inflow port by directing the water received from the aquatic application to flow into both the heater bypass and the first inflow port.

6. The connected heating system of claim 5, wherein the heater control board comprises the controller.

7. The connected heating system of claim 5, wherein the controller is electrically connected to the heater control board via a wireless medium.

8. The connected heating system of claim 5, wherein the controller is electrically connected to the heater control board via an RS485 connection that includes a half-duplex 485 link that operates in a listen only mode such that the heater control board is configured to transmit only when sending of data to the controller is required.

9. The connected heating system of claim 1 further comprising an actuator connected to the valve and electrically coupled to the controller, wherein the actuator is configured to actuate the valve into the operating state in response to receiving the control signals from the controller.

10. The connected heating system of claim 1, wherein the valve includes a T configuration where one opening of the valve is coupled to the first inflow port by a pipe or conduit that is substantially parallel to ground and another opening of the valve is coupled to the heater bypass, wherein the heater bypass is substantially perpendicular to the ground, and wherein, a check valve is positioned between the first outflow port and a second outflow port of the heater bypass to prevent heated

water from flowing back into the heater.

11. The connected heating system of claim 1 wherein the valve includes a T configuration where one opening of the valve is coupled to the first inflow port by a pipe or conduit that is substantially parallel to ground and another opening of the valve is coupled to the heater bypass, wherein the heater bypass is substantially perpendicular to the ground, and wherein, a check valve is positioned between the first outflow port and a second outflow port of the heater bypass to prevent heated water from flowing back into the heater.

12. A connected heating system for a swimming pool, comprising a heater having a housing, a first inflow port in fluid communication with the housing, a first outflow port in fluid communication, a heater control board disposed inside the housing, an ignition control module electrically connected to the heater control board and disposed inside the housing, a burner disposed inside the housing, and a blower motor disposed inside the housing; a controller that monitors a temperature of water flowing between the inflow port and the outflow port of the heater; a heater bypass coupled between the first inflow port and the first outflow port; and a valve that controls flow of water received from a pool into the first inflow port and the heater bypass based on an operating state identified by the controller, wherein, responsive to the controller identifying the operating state, the controller is configured to transmit control signals that direct actuation of the valve to achieve the operating state, and wherein the heater is configured to engage a heating mode to heat portions of the water from the pool that flow between the first inflow port and the first outflow port by activating the blower motor and directing the ignition control module to ignite the burner.

13. The connected heating system of claim 12, wherein the operating state includes one of a plurality of actuation states of the valve, the plurality of actuation states of the valve including a fully closed state, a fully open state, and one or more intermediate states, wherein, in the fully closed state, the valve directs the water received from the pool to flow into the heater bypass by blocking flow into the first inflow port, wherein, in the fully open state, the valve enables water to flow freely into the first inflow port by blocking flow into the heater bypass, and wherein, in the one or more intermediate states, the valve attenuates flow of the water from the pool into the first inflow port by directing the water received from the pool to flow into both the heater bypass and the first inflow port.

14. The connected heating system of claim 12 further comprising a water temperature sensor electrically coupled to the controller, wherein the water temperature sensor measures and relays to the controller a temperature of the water flowing between the first inflow port and the first outflow port, wherein, when the controller determines that the temperature of the water is below a first preconfigured threshold, the heater control board engages the heating mode and the controller identifies the operating state as a fully open state where the valve enables the water from the pool to flow freely into the first inflow port by blocking flow into the heater bypass, wherein when the controller determines that the temperature of the water is above a second preconfigured threshold the heater control board disengages the heating mode and the controller identifies the operating state as an intermediate state where the valve attenuates flow of the water from the pool into the first inflow port by directing the water received from the pool to flow into both the heater bypass and the first inflow port.

15. The connected heating system of claim 12, wherein the heater control board comprises the controller.

16. The connected heating system of claim 12, wherein the controller is electrically connected to the heater control board via a wireless medium.

17. The connected heating system of claim 12, wherein the controller is electrically connected to the heater control board via an RS485 connection that includes a half-duplex 485 link that operates in a listen only mode such that the heater control board is configured to transmit only when sending of data to the controller is required.

18. A method of operating a heater, comprising: monitoring a temperature of water flowing

between an inflow port and an outflow port of the heater via a controller and a sensor in communication with the controller; engaging a heating mode of the heater to heat the water flowing between the inflow port and the outflow port via a heater control board of the heater when the controller determines that the temperature of the water is below a first preconfigured temperature threshold; sending a first control signal to actuate a valve into a fully open state where the valve enables the water to flow freely into the first-inflow port by blocking flow into a heater bypass when the heating mode is engaged; disengaging the heating mode of the heater when the controller determines that the temperature of the water is above a second preconfigured temperature threshold; and sending a second control signal to actuate the valve into an intermediate state where the valve attenuates flow of the water into the inflow port by directing the water to flow into both the heater bypass and the first inflow port when the heating mode is disengaged.

19. The method of claim 18, wherein the first preconfigured temperature is the same as the second preconfigured temperature.

20. The method of claim 18, wherein the controller is electrically connected to the heater control board via an RS485 connection that includes a half-duplex 485 link that operates in a listen only mode such that the heater control board is configured to transmit only when sending of data to the controller is required.
