United States Patent	12392152
Kind Code	B2
Date of Patent	August 19, 2025
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Swimming pool pressure and flow control pumping and water distribution systems and methods

Abstract

Pumping and water distribution systems for pools/spas, and methods for control thereof are provided. A system includes a pump including a variable speed motor, a controller configured to control the speed of the motor, a plurality of pool/spa components, a plumbing subsystem placing the components in fluidic communication with the pump, and a plurality of control valves switchable between an open position and a closed position. Each of the control valves is associated with one of the components, positioned in the plumbing subsystem between the associated component and the pump to control the flow of fluid to the associated component, and is configured to provide a specific flow rate of fluid to the associated component based on a set system pressure when in the open position. The controller adjusts the speed of the motor to adjust the fluid pressure within the plumbing subsystem to match the set system pressure value.

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Appl. No.:	**17/642606**
Filed (or PCT Filed):	**September 11, 2020**
PCT No.:	**PCT/US2020/050481**
PCT Pub. No.:	**WO2021/050932**
PCT Pub. Date:	March 18, 2021

Prior Publication Data

Document Identifier US 20220341202 A1 | **Publication Date** Oct. 27, 2022

Related U.S. Application Data

us-provisional-application US 62899021 20190911

Publication Classification

Int. Cl.: **E04H4/12** (20060101); **G05D7/06** (20060101)

U.S. Cl.:

CPC **E04H4/12** (20130101); **G05D7/0688** (20130101);

Field of Classification Search

CPC: E04H (4/12); G05D (7/0688)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) The present application is a U.S. National Phase Application under 35 U.S.C. § 371 of International Application No. PCT/US2020/050481 filed on Sep. 11, 2020, which claims the benefit of priority to U.S. Provisional Patent Application Ser. No. 62/899,021, filed on Sep. 11, 2019, the entire disclosures of which are hereby incorporated by reference.

TECHNICAL FIELD
(1) The present disclosure relates generally to systems and methods for pressure and flow control in pool and spa equipment. More specifically, the present disclosure relates to swimming pool pressure and flow control pumping and water distribution systems and methods.
RELATED ART
(2) Typically, in the pool and spa field, current applications of variable speed pumps within the swimming pool environment do not supply predictable and precise water flow to all combinations of pool/spa equipment. Generally, in prior art systems, the desired flow to various pool/spa system components (e.g., pool/spa equipment) is established during initial system set-up by assigning a given pump RPM (revolutions per minute) operating parameter based on published pump performance curve estimates in order to achieve a given flow. However, determining flow settings for multiple components in a single system can sometimes be unpredictable, which can result in improper flow being provided to the components and cause poor performance and efficiency of the pool/spa pumping and distribution system. The result is a pool/spa system that does not properly operate and utilizes excessive energy. Further, the operational configuration of current variable speed pump technology does not always achieve the intended variable speed benefit, as such pumps might not always operate at the lowest possible motor speed or conserve pump motor horsepower energy. In some instances, an operator may set a variable speed pump to an RPM value and a flow value that is below the specified flow requirement of a single component or grouping of components hoping to save energy. However, the actual result is that the associated components might underperform or not perform at all, which can result in excessive run times, system inefficiency, and increased power usage. Additionally, in some scenarios, total GPM (gallons per minute) required by the components might exceed the maximum capacity of the pump, e.g., when multiple system component's demands exceed pump capacity. In such situations, the total GPM flow is reduced to all components, which can further reduce performance and proper system operation, and waste pump motor energy.
(3) Moreover, pool system components typically require specific flow for optimal performance and efficiency. However, current “non-smart” variable speed pumping technology can sometimes operate independent of system component requirements, and instead vary the flow based on a programmed setting or component control interlock. In such systems, exact flow to each component is often unknown and unpredictable based on system variables. This can result in pool components performing based on a separately programmed pump speed and associated valve, which might allow for flows higher or lower than component requirements.
(4) Accordingly, what is desired is a system that provides proper and specified flow to maximize pool/spa component efficiency and performance, maximizes variable speed pump energy efficiency, and considers individual system component specified requirements in determining required flow of a variable speed pump. As such, it is desirable to provide pool and spa owners

with swimming pool/spa pressure and flow control pumping and water distribution systems and methods, which solve these and other needs.

SUMMARY

(5) The present disclosure relates to swimming pool pressure and flow control pumping and water distribution systems and methods. Specifically, the present disclosure relates to pumping and water distribution systems for movement of water in a swimming pool or spa that can provide a specific and predictable water flow to various swimming pool components in multiple and varied configurations of independent and simultaneous operation. Embodiments of the invention can include a variable speed pump controlled by dynamic or calibrated speed control to achieve specific flows at a given system pressure. Additional embodiments can include an adjustable and modifiable fluid circuit/component control valve that is automatically or manually adjustable to operate at a specific pressure and flow, and operates as an on/off control valve. The system can allow the system pump to provide the minimum flow possible to provide exact and specified flow to each swimming pool component being supplied by the pump, while operating the system pump at the lowest speed (e.g., RPM value) necessary to provide the required specified flow to maximize energy efficiency. Each swimming pool component, when activated, can receive a precise specified flow to maximize performance and efficiency.

(6) Furthermore, the system of the present disclosure can provide precise specified water flow to pool system components while continuously seeking the lowest possible pump motor speed. Pump speed can be based on water flow requirements of the system components in lieu of a time clock or other programming mechanism governing the pump speed with no direct feedback or interlock to component flow performance. As such, the system of the present disclosure can exploit the benefit of variable speed pumping to adjust motor speeds incrementally and in real-time based on system needs to provide a precise system flow, while minimizing energy consumption of the pump. Further, the control system can provide automatic calibration and set-up of the component control valves and system parameters. Still further, in accordance with some embodiments of the present disclosure, the control system can prioritize the pool system components, determine if a current total flow requirement for a plurality of activated pool system components exceeds a flow capacity of the pump, and deactivate the component having the lowest priority value if the current total flow requirement exceeds the flow capacity of the pump.

(7) In accordance with embodiments of the present disclosure, a pumping and water distribution system for a pool or spa includes a pump including a variable speed motor, a controller configured to control the speed of the variable speed motor, a plurality of pool/spa components, a plumbing subsystem placing the plurality of pool/spa components in fluidic communication with the pump, and a plurality of control valves each switchable between an open position and a closed position. The controller can store a set system pressure value that can be used for adjusting the speed of the variable speed motor. Each of the plurality of control valves can be associated with one of the plurality of pool/spa components and can be positioned in the plumbing subsystem between the associated pool/spa component and the pump in order to control the flow of fluid to the associated pool/spa component. Each of the plurality of control valves can be configured to provide a specific flow rate of fluid to the associated pool/spa component based on a set system pressure when in the open position. The controller can adjust the speed of the variable speed motor in order to adjust a pressure of fluid within the plumbing subsystem to match the set system pressure value.

(8) In accordance with other embodiments of the present disclosure, a method for controlling a pool or spa pumping system is provided. Information can be received at a controller and can include a set system pressure value and a required flow rate of each of a plurality of pool/spa components. A plurality of control valves each switchable between an open position and a closed position can be provided. Each of the plurality of control valves can then be associated with one of the plurality of pool/spa components based on the information in order to provide a specific flow rate of fluid to the associated pool/spa component based on the set system pressure when the control valve is in

the open position. Each of the plurality of control valves can be positioned in a plumbing subsystem between the associated pool/spa component and a pump in order to control the flow of fluid to the associated pool/spa component. The speed of a variable speed motor of the pump can be adjusted in order to adjust a pressure of fluid within the plumbing subsystem to match the set system pressure value.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The foregoing features of the invention will be apparent from the following Detailed Description, taken in connection with the accompanying drawings, in which:
(2) FIG. **1** is a diagram illustrating a pool/spa system of the present disclosure;
(3) FIG. **2** is a flowchart illustrating process steps carried out by the pool/spa system of the present disclosure during a set-up and calibration mode;
(4) FIG. **3** is a flowchart illustrating process steps carried out by the pool/spa system of the present disclosure for performing a dynamic pressure control mode of operation;
(5) FIG. **4** is a schematic diagram showing a first embodiment of a pool/spa system of the present disclosure in the dynamic pressure control mode of operation;
(6) FIG. **5** is a schematic diagram showing a second embodiment of a pool/spa system of the present disclosure in a programmed RPM set point control mode of operation;
(7) FIG. **6** is a schematic diagram showing a third embodiment of a pool/spa system of the present disclosure including manual component pressure set-up with automatic ON/OFF component and pump control; and
(8) FIG. **7** is a schematic diagram showing a fourth embodiment of a pool/spa system including manual component pressure set-up with manual ON/OFF component control and automatic pump control.
DETAILED DESCRIPTION
(9) The present disclosure relates to swimming pool pressure and flow control pumping and water distribution systems and methods, as described in detail below in connection with FIGS. **1-7**.
(10) FIG. **1** is a diagram illustrating a pool/spa system of the present disclosure, indicated generally at system **10**. The system **10** includes a pump system **12**, a sensing hub **13**, a control system **22**, control valves **30***a*-**30***n*, and components **32***a*-**32***n*. The pump system **12** includes a variable speed pump (“VSP”) **14** and a variable speed pump controller **16**, and can be electrically connected to the control system **22**. The sensing hub **13** includes a pressure sensor **18**, and a flow meter **20**, such as a digital flow meter, an analog flow meter, etc., and can be electrically connected to the control system **22**. The pressure sensor **18** and the flow meter **20** can be positioned in a water return pipe, such that the pressure sensor **18** can provide system pressure data and the flow meter **20** can provide flow data to the control system **22**. It is noted that the pump controller **16**, the pressure sensor **18**, and the digital flow meter **20** can be affixed to, installed within, or located remotely from the variable speed pump **14**, and can be digitally or wirelessly connected to the variable speed pump **14**. It is additionally noted that, while the pressure sensor **18** and the flow meter **20** are shown as being included in the pump system **12**, these components can be separate therefrom and/or connected directly to the control system **22**.
(11) The variable speed pump **14** provides water from a pool/spa to the components **32***a*-**32***n*, e.g., via piping or a plumbing subsystem that includes one or more pipes. The components **32***a*-**32***n* can include H.sub.2O features, pool/spa jets, an in-floor cleaning system, water features, a heater, a filter, a chlorinator, a chemical feeder, a sterilizer (e.g., an ultraviolet sterilizer, an ozone sterilizer, or a combination ultraviolet and ozone sterilizer), a pool cleaner, etc. The flow of water to each component **32***a*-**32***n* is controlled via a corresponding control valve **30***a*-**30***n* using a pressure/flow

control and on/off motorized functions. Each component **32***a*-**32***n* can be designated as an essential component or a non-essential component. As will be explained in greater detail below, the control system **22** can prioritize essential components over non-essential components when available water pressure is limited, e.g., during operation or prior to activating an additional component.

(12) The control system **22** can include a processor **24** in communication with a memory **26** including at least one of a random-access memory and a non-volatile memory. For example, the control system **22** can be an OmniLogic® or OmniHub® controller manufactured and sold by Hayward Industries, Inc. The processor **24** provides local processing capability for the control system **22**. The memory **26** can store one or more local control programs for providing automated system setup, balance and calibration setup, and control of pool and spa equipment (e.g., the pump system **12**, the control valves **30***a*-**30***n*, the components **32***a*-**32***n*, etc.). The processor **24** is in communication with the pump system **12**, the control valves **30***a*-**30***n*, and the components **32***a*-**32***n*, e.g., via a digital or a wireless signal. It is also noted that in some embodiments the control valves **30***a*-**30***n* and the components **32***a*-**32***n* can instead be in electrical communication with, and controlled by, the variable speed pump controller **16** instead of the control system **22**. In other embodiments, one or more of the components **32***a*-**32***n* may not be controlled by the control system **22**, but instead may be controlled by a separate, e.g., remote, controller or no controller at all. For example, some components **32***a*-**32***n* may be solely fluid controlled such that they operate based on whether pressurized fluid is provided thereto. Such components may therefore be controlled by whether the associated control valve **30***a*-**30***n* is open or closed, and are not electrically controlled, e.g., by a controller. The control valves **30***a*-**30***n* can be activated manual or by automated control from the control system **22** via the processor **24**. In some embodiments, the control valves **30***a*-**30***n* can be manual valves that are not connected with the control system **22**, but instead are manually actuated by a user or a technician. The processor **24** can detect changes in the water pressure and/or in the water flow at a position downstream the outlet of the variable speed pump **14** using the pressure sensor **18** and/or the flow meter **20**. For example, the outlet of the variable speed pump **14** can be connected to a main fluid return line of a pool/spa plumbing system, which is in fluidic communication with the control valves **30***a*-**30***n* and the components **32***a*-**32***n* via one or more pipes. In such a configuration, the pressure sensor **18** can be positioned within the main fluid return line to detect system pressure. It should also be understood that additional components may be controlled by the control system **22** independently or in response to a particular control valve **30***a*-**30***n* or component **32***a*-**32***n* being activated. For example, if the component **32***a* is a heater, then the control system **22** can open an associated gas valve or relay required for proper operation of the heater in addition to the associated control valve **30***a*.

(13) The system **10** can further include a display, such as a touchscreen, a screen with a touchpad, etc. The display can be affixed to, installed within, or installed remotely from the pump system **12** or the control system **22**. The display can receive user input via, for example, the touch screen, a keyboard, a remote or wireless input device, etc. The display can further show diagnostic issues, messages, instructions, etc.

(14) The system **10** is configured to provide precise flow to each component **32***a*-**32***n* at a set system pressure while maintaining the minimum necessary pump speed and energy usage to provide the required flow to each of the components **32***a*-**32***n*. This is achieved by adjusting the speed of the motor of the variable speed pump **14** in real-time to the value necessary to provide the required flow to each of the components **32***a*-**32***n* based on which control valves **30***a*-**30***n* are open or closed, which is discussed in greater detail below.

(15) As discussed above, each of the components **32***a*-**32***n* is in fluidic communication with the variable speed pump **14**, such that the variable speed pump **14** provides pressurized water thereto for operation. Accordingly, all of the components **32***a*-**32***n* are connected with the same piping system as the variable speed pump **14**. The components **32***a*-**32***n* can operate at a standard pre-determined system pressure, which can be established by determining the component **32***a*-**32***n* in

the system that has the highest pressure loss during operation. For example, if the highest pressure loss component utilized within a pool is an in-floor cleaning system that has a total pressure loss of 21 PSI at a specified flow rate of 68 GPM, then the control system **22** can establish 21 PSI as the system pressure set point to be utilized.

(16) The control system **22** can perform an initial set-up process that allows for establishing the system pressure and calibrates the control valves **30***a*-**30***n*. Specifically, the control system **22**, in dynamic or set-up operation, can calibrate the flow provided to each component **32***a*-**32***n* at the set system pressure by adjusting each associated control valve **30***a*-**30***n*. The control valves **30***a*-**30***n* can be single valves that control pressure and flow, as well as on/off functionality, or can be two separate valves where one valve provides a desired flow at a given pressure and a second valve is an on/off valve. Further, the control valves **30***a*-**30***n* can be non-adjustable set valves that provide a certain flow at a certain pressure and would, therefore, be specific to the component that they are associated with, or the valves can be electrically or manually adjustable valves, e.g., via a disc insert, adjustable screw setting, etc. Accordingly, the control valves **30***a*-**30***n* can include an adjustable pressure setting to provide the required resistance for each of the components **32***a*-**32***n* to be equalized to the system pressure utilizing the following criteria: (Component/line loss pressure)+(valve pressure setting at the specified flow)=system pressure; where system pressure is equal to the highest component pressure loss, as discussed above. When the control valve **30***a*-**30***n* is calibrated, it can allow a specified flow at a given pressure. Additionally, not only can the control valves **30***a*-**30***n* be calibrated based on the flow required by the associated component **32***a*-**32***n* for proper performance, they can also be calibrated based on a discretionary flow value to adjust performance of the associated component **32***a*-**32***n* based on a user's desire. For example, a water feature might be operable within a range of flow values such that a lower flow value results in one operation and a higher flow value results in a second operation, e.g., the water feature might discharge water different distances depending on how much flow is provided thereto. Accordingly, during set-up, the control valves **30***a*-**30***n* can be calibrated based on a desired operation or performance of the associated component **32***a*-**32***n*.

(17) Accordingly, the control valve **30***a*-**30***n*, when in the open position, will provide the specified component flow at the specified system pressure to the associated component **32***a*-**32***n* for which it has been calibrated. Once initial set-up has been performed, as discussed above, the control valves **30***a*-**30***n* will operate as an on/off valve in normal operational use. During operation, as control valves **30***a*-**30***n* are opened and closed, the variable speed pump **14** will increase or decrease motor speed (e.g., motor RPM) to meet the required system pressure set point. Thus, the system pressure set point is maintained by increasing and decreasing the pump speed of the variable speed pump **14** in response to the opening and closing of control valves **30***a*-**30***n*. The processor **24** determines whether the variable speed pump **14** is providing the set system pressure based on the pressure sensor **18**. When the specified system pressure is maintained via motor speed settings of the variable speed pump **14**, utilizing system pressure dynamic or static set points, the system **10** achieves precise flow to the components **32***a*-**32***n* while maintaining the lowest possible motor speed. Thus, during normal operation, the variable speed pump **14** will operate at the lowest RPM value necessary to provide the specified system pressure.

(18) Additionally, in a situation where the cumulative flow requirement of the components **32***a*-**32***n* currently operating exceeds total pump flow capacity, the control system **22** can deprioritize non-essential components and delay or pause operation thereof. When an essential (e.g., high priority) component's run cycle is complete, the non-essential (e.g., lower priority) component's operation can begin/resume. Additionally, the control system **22** can determine the current cumulative flow requirements of the components **32***a*-**32***n* currently operating, and can prevent additional control valves **30***a*-**30***n* and components **32***a*-**32***n* from being activated if activation of such control valve **30***a*-**30***n* and component **32***a*-**32***n* would result in the cumulative flow requirement exceeding the total pump flow capacity. Alternatively, in such a configuration, the control system **22** could allow

the new control valve **30***a*-**30***n* and component **32***a*-**32***n* to be activated, but in turn deactivate a different control valve **30***a*-**30***n* and component **32***a*-**32***n* that has a lesser priority in order to allow the higher priority components **32**-**32***n* to operate but not allow the cumulative flow requirement to exceed the total pump flow capacity.

(19) FIG. **2** is a flowchart illustrating process steps carried out by the system **10** of the present disclosure during a set-up and calibration mode, indicated generally at method **40**. In step **42**, a user inputs system information into the control system **22**. For example, the user can enter into the control system **22** the required flow rate of each component **32***a*-**32***n*, and a system pressure value, as prompted by the display of the control system **22** through an automatic set-up feature. As discussed above, the set system pressure value can be the pressure loss of the component **32***a*-**32***n* having the highest pressure loss during operation.

(20) In step **44**, the control system **22** performs an automatic set-up of each component **32***a*-**32***n* fluid circuit to provide the exact flow at the set system pressure. For example, utilizing inputs to and from the pressure sensor **18**, the flow meter **20**, the variable speed pump **14**, and/or the control valves **30***a*-**30***n*, the control system **22** can automatically calibrate each of the control valves **30***a*-**30***n* so that they provide the necessary flow for operation of the associated component **32***a*-**32***n* at the set system pressure. Alternatively, the control valves **30***a*-**30***n* can be manually set by a field technician based on prompts from the control system **22**. The following considerations can be taken into account when calibrating the valves **30***a*-**30***n:* 1) the component **32***a*-**32***n* with the highest loss will not require a flow control device, but instead only requires an on/off control valve due to the system pressure setting being equal to the highest loss component and no additional pressure being introduced to that component; and 2) all remaining control valves will be equalized to the system pressure setting or the highest loss component utilizing the following formula: (Component pressure loss)+(added adjusted loss via the flow control valve at the required component GPM)=established system pressure. Finally, in step **46**, the system **10** engages a mode of operation. The mode of operation can include a dynamic pressure control mode of operation, a programmed RPM set point control mode of operation, an automatic system component underflow management mode of operation, a regular mode of operation, or other modes of operation. The modes of operation will be discussed in further detail below.

(21) FIG. **3** is a flowchart illustrating process steps carried out by the system **10** of the present disclosure to perform the dynamic pressure control mode of operation, indicated generally at method **50**. In step **52**, the system **10** operates at the set system pressure. For example, the variable speed pump **14** can operate at a certain speed to achieve the set system pressure. In step **54**, the system **10** determines a current system pressure using the pressure sensor **18**. In step **56**, the system determines whether the current system pressure is different from the set system pressure (e.g., whether the current system pressure is greater or less than the set system pressure). If it is determined that there is no pressure difference, or the pressure difference does not exceed a predetermined threshold, then the system **10** returns back to step **52** and continues to monitor the system pressure. If the system **10** determines there is a pressure difference, then the system **10** proceeds to step **58**, where the system **10** adjusts the speed (e.g., increases the RPMs or decreases the RPMs) of the motor of the variable speed pump **14**. Specifically, the system **10** adjusts the speed of the motor to increase or decrease the system pressure to equal that of the established system pressure valve.

(22) As discussed above, the system pressure will increase or decrease depending on which of the control valves **30***a*-**30***n* are opened or closed based on, for example, a timed schedule or user inputs via the control system **22**. For example, when a control valve **30***a*-**30***n* is closed, a system pressure higher than the system pressure set point forms. Using the dynamic pressure control mode of operation described in connection with method **50**, the system **10**, via the pressure sensor **18**, will sense the change in pressure and the variable speed pump **14** will increase or decrease its motor speed to meet and maintain the system pressure set point. As such, by maintaining the system

pressure and calibrating the control valves **30***a*-**30***n* to the set system pressure, a predictable and reliable flow will be achieved at each component **32***a*-**32***n* when its control valve **30***a*-**30***n* is in the open position, thus providing the most efficient operation and proper system and component **32***a*-**32***n* performance. With component flow optimized, the components **32***a*-**32***n* will perform required functions in reduced time periods and allow significant reductions of variable speed pump **14** usage durations and variable speed pump **14** motor power consumption.
(23) FIG. **4** is a schematic diagram showing a first embodiment of a system **60** in the dynamic pressure control mode of operation. As shown in FIG. **4** the system **60** includes a variable speed pump **62**, a pump controller **64**, a control system **66**, a pressure sensor **68**, a flow meter **70**, a plurality of control valves **72***a*-**72***e*, and a plurality of components **74***a*-**74***e*. A pool suction main pipe **75** is connected to an inlet of the variable speed pump **62**, and a pool return main pipe **76** is connected to an outlet of the variable speed pump **62**, such that water is drawn from a pool through the pool suction main pipe **75** into the variable speed pump **62**, and discharged from the variable speed pump **62** through the pool return main pipe **76** to the control valves **72***a*-**72***e*, which control the flow of water to the components **74***a*-**74***e*. The pool return main pipe **76** can be a part of a plumbing subsystem that places the components **74***a*-**74***e* in fluidic communication with the variable speed pump **62**, and the control valves **72***a*-**72***e* can be placed in the plumbing subsystem between the components **74***a*-**74***e* and the variable speed pump **62**. The plumbing subsystem can also include branched piping extending from the pool return main pipe **76** to the components **74***a*-**74***e*. The control system **66** is connected to the control valves **72***a*-**72***c* via regular voltage wiring, and to the control valves **72***d*-**72***e* through low voltage wiring **78**. The components **74***a*-**74***e* can include H.sub.2O features **74***a*, pool/spa jets **74***b*, an in-floor cleaning system **74***c*, water features **74***d*, and other components **74***e*, such as a heater, a filter, a chlorinator, etc.
(24) The control system **66** can perform an initial set-up process that allows for establishing the system pressure and calibrates the control valves **72***a*-**72***n*, in similar fashion to that discussed in connection with FIGS. **1**-**3**. Specifically, the control system **66** can first establish a system pressure by determining the component **74***a*-**74***n* in the system **60** that has the highest pressure loss during operation and setting the system pressure to that value, and then calibrate each control valve **72***a*-**72***n* to provide the proper flow to each component **74***a*-**74***n* at the set system pressure, as discussed above in FIG. **1**. The system **60** can then provide precise flow to each component **74***a*-**74***n* at the set system pressure by adjusting the speed of the motor of the variable speed pump **62** to the value necessary to maintain the system pressure at the set system pressure value and thus provide the required flow to each of the components **74***a*-**74***n* based on which control valves **72***a*-**72***n* are open or closed. That is, as control valves **72***a*-**72***n* are opened or closed, the control system **66** will instruct the variable speed pump **62** to either increase speed (RPMs) or decrease speed (RPMs) in order to adjust the current system pressure so as to match the set system pressure value established during set-up. This is achieved by receiving pressure readings from the pressure sensor **68**, comparing the readings to the set system pressure value established during set-up, and adjusting the speed of the variable speed pump **62** until the current pressure reading of the pressure sensor **68** matches the set system pressure value.
(25) FIG. **5** is a schematic diagram showing a second embodiment of system **80** in the programmed RPM set point control mode of operation. As shown in FIG. **5**, the system **80** includes a variable speed pump **82**, a pump controller **84**, a control system **86**, a pressure sensor **88**, a flow meter **90**, a plurality of control valves **92***a*-**92***e*, and a plurality of components **94***a*-**94***e*. A pool suction main pipe **95** is connected to an inlet of the variable speed pump **82**, and a pool return main pipe **96** is connected to an outlet of the variable speed pump **82**, such that water is drawn from a pool through the pool suction main pipe **95** into the variable speed pump **82**, and discharged from the variable speed pump **82** through the pool return main pipe **96** to the control valves **92***a*-**92***e*, which control the flow of water to the components **94***a*-**94***e*. The pool return main pipe **96** can be a part of a plumbing subsystem that places the components **94***a*-**94***e* in fluidic communication with the

variable speed pump **82**, and the control valves **92***a*-**92***e* can be placed in the plumbing subsystem between the components **94***a*-**94***e* and the variable speed pump **82**. The plumbing subsystem can also include branched piping extending from the pool return main pipe **96** to the components **94***a*-**94***e*. The control system **86** is connected to the control valves **92***a*-**92***c* via regular voltage wiring, and to the control valves **92***d*-**92***e* through low voltage wiring **98**. The components **94***a*-**94***e* can include H.sub.2O features **94***a*, pool/spa jets **94***b*, an in-floor cleaning system **94***c*, water features **94***d*, and other components **94***e*, such as a heater, a filter, a chlorinator, etc.

(26) In the programmed RPM set point control mode of operation, the system **80** can utilize the pressure sensor **88**, the flow meter **90**, the controller **86**, and control valves **92***a*-**92***n* for system set-up and calibration, e.g., in similar fashion to that discussed in connection with FIG. **1**. As each the of the component circuits are calibrated, e.g., the control valves **92***a*-**92***n* are calibrated for the desired flow needed by the associated component **94***a*-**94***n*, the controller **86** records the motor speed (RPM) value required to provide the specified flow and pressure to each component **94***a*-**94***n*. Additionally, once the controller **86** has determined the required motor speed (RPM) value for operation of each component **94***a*-**94***n*, it can automatically test all configurations of component groupings to determine the motor speed (RPM) value required to provide the specified flow to each component **94***a*-**94***n* for each of the various component configurations. This determination can be based on the required motor speed (RPM) value for each component individually **94***a*-**94***n* that was previously determined by the controller **86**. For example, a first grouping can include the filter, the pool/spa jets, and the in-floor cleaning system, and a second grouping can include the filter, pool/spa jets, and the chlorinator. Once the calibration and set-up of the system component configurations are determined, the system records the required pump RPM set points for each component grouping for future use.

(27) Under normal operation, the controller **86** assigns pump RPM values to each component **94***a*-**94***n* and multiple component groupings. In this configuration, the system **80** can operate based on only pump RPM values with predictable and accurate performance. As such, the system **80** would not need to determine pressure measurements or flow measurements because the pump RPM values are predetermined for each grouping of components, and can thus operate as a sensorless/“dumb” system. The system **10** can further perform automatic recalibration of the RPM values at preset intervals determined by a user utilizing the pressure sensor.

(28) FIG. **6** is a schematic diagram showing a third embodiment of a system **100** including a manual component pressure set-up with automatic ON/OFF component and pump control. As shown in FIG. **6**, the system **100** includes a variable speed pump **102**, a pump controller **104**, a controller/control system **106**, a pressure sensor **108**, a flow meter **110**, a plurality of control valves **112***a*-**112***e*, a plurality of components **114***a*-**114***e*, and a plurality of manual volume/pressure control devices **116***a*-**116***e* (e.g., adjustable valves). A pool suction main pipe **115** is connected to an inlet of the variable speed pump **102** and a pool return main pipe **117** is connected to an outlet of the variable speed pump **102**, such that water is drawn from a pool through the pool suction main pipe **115** into the variable speed pump **102**, and out through the pool return main pipe **117** to the control valves **112***a*-**112***e*, which control the flow of water to the manual volume/pressure control devices **116***a*-**116***e* which in turn control the flow of water to the components **114***a*-**114***e*. The pool return main pipe **117** can be a part of a plumbing subsystem that places the components **114***a*-**114***e* in fluidic communication with the variable speed pump **102**, and the control valves **112***a*-**112***e* and the manual volume/pressure control devices **116***a*-**116***e* can be placed in the plumbing subsystem between the components **114***a*-**114***e* and the variable speed pump **102**. The plumbing subsystem can also include branched piping extending from the pool return main pipe **117** to the components **114***a*-**114***e*. The control system **106** is connected to the control valves **112***a*-**112***c* via regular voltage wiring, and to the control valves **112***d*-**112***e* through low voltage wiring **118**. The components **114***a*-**114***e* can include H.sub.2O features **114***a*, pool/spa jets **114***b*, an in-floor cleaning system **114***c*, water features **114***d*, and other components **114***e*, such as a heater, a filter, a chlorinator, etc.

(29) The control system **106** can use the pressure sensor **108**, the flow meter **110**, the control valves **112***a*-**112***e*, and the manual volume/pressure control devices **116***a*-**116***e* for set-up and calibration. Specifically, control valve pressure set points can be manually adjusted by a user (e.g., a set-up technician, a repairman, a pool owner, etc.) utilizing the manual volume/pressure control devices **116***a*-**116***e*. The manual volume/pressure control devices **116***a*-**116***e* can be adjustable valves that can be adjusted by a technician to provide the desired flow at the set system pressure for the associated component **114***a*-**114***e*. For example, the technician can adjust the adjustable valve based on prompts from the control system **106** until the desired settings are attained. Once set, the manual volume/pressure control devices **116***a*-**116***e* are not adjusted by the system controller **106**, but during normal operation, the system controller **106** will operate the control valves **112***a*-**112***e*, which can be on/off valves, to direct water flow to the associated component **114***a*-**114***e*.
(30) Furthermore, the system **100** can operate in the programmed RPM set point control mode of operation discussed above in connection with FIG. **5**. In this mode, the control system **106** records required pump RPM set points to provide specified flow and pressure to each component **114***a*-**114***e*. Additionally, the control system **106** can test all configurations of component groupings to determine the RPM value necessary to provide the flow required for each component configuration. Once the system **100** calibrates the manual volume/pressure control devices **116***a*-**116***e* and sets the system component configurations, the required pump RPM set points for each component and configuration are recorded by the control system **106**. As such, the system **100** can be operated based on only pump RPM values with predictable and accurate performance. This eliminates the need for the pressure sensor **108** to be used during everyday operation. Additionally, the valves and RPM values can be manually recalibrated based on user determined intervals to ensure that the components **114***a*-**114***e* are being provided with the correct flow and are operating optimally.
(31) FIG. **7** is a schematic diagram showing a fourth embodiment of a pool/spa system **120** including manual component pressure set-up with manual ON/OFF component control and automatic pump control. As shown in FIG. **7**, the system **120** includes a variable speed pump **122**, a pump controller **124**, a pressure sensor **126**, control valves **128***a*-**128***e*, components **130***a*-**130***e*, manual volume/pressure control devices **132***a*-**132***e*, and low voltage wiring **138**. The pump controller **124** can use the pressure sensor **126**, the control valves **128***a*-**128***e*, the components **130***a*-**130***e*, and the manual volume/pressure control devices **132***a*-**132***e* (e.g., adjustable valves), along with external system set-up instrumentation, to set-up and calibrate the system **120**. A pool suction main pipe **134** is connected to an inlet of the variable speed pump **122** and a pool return main pipe **136** is connected to an outlet of the variable speed pump **122**, such that water is drawn from a pool through the pool suction main pipe **134** into the variable speed pump **122**, and out through the pool return main pipe **136** to the control valves **128***a*-**128***e*, which control the flow of water to the manual volume/pressure control devices **132***a*-**132***e* which in turn control the flow of water to the components **130***a*-**130***e*. The pool return main pipe **136** can be a part of a plumbing subsystem that places the components **130***a*-**130***e* in fluidic communication with the variable speed pump **122**, and the control valves **128***a*-**128***e* and the manual volume/pressure control devices **132***a*-**132***e* can be placed in the plumbing subsystem between the components **130***a*-**130***e* and the variable speed pump **122**. The plumbing subsystem can also include branched piping extending from the pool return main pipe **136** to the components **130***a*-**130***e*. The components **130***a*-**130***e* can include H.sub.2O features **130***a*, pool/spa jets **130***b*, an in-floor cleaning system **130***c*, water features **130***d*, and other components **130***e*, such as a heater, a filter, a chlorinator, etc.
(32) The manual volume/pressure control devices **132***a*-**132***e* can be adjustable valves that can be set-up and calibrated by a technician to provide the desired flow at the set system pressure for the associated component **130***a*-**130***e*. For example, the technician can adjust the manual volume/pressure control devices **132***a*-**132***e* based on prompts from a remote calibration and set-up instrument until the desired settings are attained. Once the calibration and set-up of the manual volume/pressure control devices **132***a*-**132***e* is finished, and the system pressure is set, the required

system pressure set points are input into the pump controller **124**. This allows for manual recalibration based on user determined intervals. Further, once set, the user can manually operate the control valves **128***a*-**128***e*, which can be on/off valves, to allow water to flow to the associated manual volume/pressure control devices **132***a*-**132***e* and thus to the associated component **130***a*-**130***e*.
(33) In this configuration, the user manually turns on and off the control valves **128***a*-**128***e* to turn on or off the associated components **130***a*-**130***e*. In response to the opening and closing of valves **128***a*-**128***e*, the variable speed pump **122** will speed up or slow down to achieve the pre-set desired system pressure as read by the pressure sensor **126**. The system **120** will perform substantially more efficient than normal non-calibrated, manually controlled pool systems because it utilizes precise pressure and flow settings on component circuits, allowing the variable speed pump **122** to operate at the lowest possible speed necessary to provide the specified and calibrated flow. Accordingly, the components **130***a*-**130***e* will operate at peak efficiency, and the minimum pump speeds and motor horsepower will be utilized to perform required pool operations.
(34) The systems **10**, **60**, **80**, **100**, **120** can also include an automatic system component underflow management mode of operation, which takes into account component priority. Specifically, when the cumulative/total flow required for all components **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e* desired to operate simultaneously exceeds the flow capacity of the respective variable speed pump **14**, **62**, **82**, **102**, **122** (or a combination of the variable speed pump **14**, **62**, **82**, **102**, **122** and additional pumps) at a given system pressure, the flow produced by the pump **14**, **62**, **82**, **102**, **122** will not meet the components' **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e* flow demand. Typically, when component flow demand exceeds available pump flow, there is a system wide reduction of flow to all components, which can cause poor operation and non-functioning components and system inefficiencies. In the automatic system component underflow management mode of operation, if the system pressure cannot be maintained, or if the pre-programmed RPM value exceeds the capacity of the variable speed pump **14**, **62**, **82**, **102**, **122**, the control system **22**, **66**, **86**, **102**, **122** will recognize an under pressure condition and will prioritize the components **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e* to assure proper component flow.
(35) During prioritization, lower priority components will be paused and put on stand-by until higher priority functions and run cycles are complete. Accordingly, available flow capacity will be utilized to provide proper operation of the priority components. The control system **22**, **66**, **86**, **102**, **122** will prevent the lower priority component(s) from resuming operation until the prescribed or user defined duration of the higher priority component(s) is completed. For example, if the pool is being operated in high demand, and the user activates water features and spa jets during the normal time period of the in-floor cleaning operation, such that the pump cannot maintain system pressure, the control system **22**, **66**, **86**, **102**, **122** will recognize an underflow condition. Upon recognizing an underflow condition, the control system **22**, **66**, **86**, **102**, **122** will pause a lower priority or non-critical component, such as the in-floor cleaning system, to reduce the flow required so that the variable speed pump **14**, **62**, **82**, **102**, **122** can maintain proper system pressure and flow to the higher priority, user prescribed components, such as the water features and the spa jets. When those higher priority components are no longer being used, the control system **22**, **66**, **86**, **102**, **122** then resumes the in-floor system operation and completes the prescribed cleaning cycle(s) and duration. A priority level of each component can be set by the user, for example, during the initial setup procedure.
(36) Additionally, the foregoing priority control operation can be implemented dynamically or statically. For example, during a dynamic implementation, if the control system **22**, **66**, **86**, **102**, **122** determines an underflow condition during operation, and the pump motor is operating at its maximum speed, then the control system **22**, **66**, **86**, **102**, **122** will pause operation of a lower priority or non-critical component. During a static implementation, the control system **22**, **66**, **86**, **102**, **122** will prevent additional components **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e*

and control valves **30***a*-**30***n*, **72***a*-**72***e*, **92***a*-**92***e*, **112***a*-**112***e*, **128***a*-**128***e* from being activated if activation of such would create an underflow condition. More specifically, the control system **22**, **66**, **86**, **102**, **122** determines the current cumulative flow requirements of the components **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e* presently operating, and will prevent additional control valves **30***a*-**30***n*, **72***a*-**72***e*, **92***a*-**92***e*, **112***a*-**112***e*, **128***a*-**128***e* and components **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e* from being activated if activation of such control valve **30***a*-**30***n* and component **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e* would cause the cumulative flow requirement to exceed the total pump flow capacity. Alternatively, in such a configuration, the control system **22**, **66**, **86**, **102**, **122** could allow the new control valve **30***a*-**30***n*, **72***a*-**72***e*, **92***a*-**92***e*, **112***a*-**112***e*, **128***a*-**128***e* and component **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e* to be activated, but in turn deactivate a different control valve **30***a*-**30***n*, **72***a*-**72***e*, **92***a*-**92***e*, **112***a*-**112***e*, **128***a*-**128***e* and component **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e* that has a lesser priority in order to allow the higher priority components **32***a*-**32***n*, **74***a*-**74***e*, **94***a*-**94***e*, **114***a*-**114***e*, **130***a*-**130***e* to operate but not allow the cumulative flow requirement to exceed the total pump flow capacity.

(37) Having thus described the system and method in detail, it is to be understood that the foregoing description is not intended to limit the spirit or scope thereof. It will be understood that the embodiments of the present disclosure described herein are merely exemplary and that a person skilled in the art can make any variations and modification without departing from the spirit and scope of the disclosure. All such variations and modifications, including those discussed above, are intended to be included within the scope of the disclosure.

Claims

1. A pumping and water distribution system for a pool or spa, comprising: a pump including a variable speed motor; a controller controlling the speed of the variable speed motor; a plurality of pool/spa components; a plumbing subsystem placing the plurality of pool/spa components in fluidic communication with the pump; and a plurality of control valves switchable between an open position and a closed position, wherein each of the plurality of control valves is associated with one of the plurality of pool/spa components, is positioned in the plumbing subsystem between the associated pool/spa component and the pump, and controls the flow of fluid to the associated pool/spa component, wherein each of the plurality of control valves is adjustable and calibratable such that each of the plurality of control valves is capable of providing different flow rates based on a set system pressure when in the open position, wherein the controller adjusts each of the plurality of control valves, and calibrates each of the plurality of control valves based on the set system pressure and a required flow rate of the associated pool/spa component such that each of the plurality of control valves provides a specific flow rate of fluid to the associated pool/spa component based on the set system pressure when in the open position, and wherein the controller adjusts the speed of the variable speed motor thereby adjusting a pressure of fluid within the plumbing subsystem to the set system pressure.
2. The pumping and water distribution system of claim 1, comprising a pressure sensor, wherein the pressure sensor senses the fluid pressure within the plumbing subsystem and provides a measurement of the sensed fluid pressure to the controller.
3. The pumping and water distribution system of claim 2, wherein the controller compares the fluid pressure measurement provided by the pressure sensor to the set system pressure, determines if the fluid pressure measurement is different than the set system pressure, and adjusts the speed of the variable speed motor if it is determined that the fluid pressure measurement is different than the set system pressure.
4. The pumping and water distribution system of claim 2, comprising a flow meter, wherein the flow meter senses the flow rate of the fluid within the plumbing subsystem and provides a

measurement of the sensed fluid flow rate to the controller.
5. The pumping and water distribution system of claim 1, wherein the controller individually switches each of the plurality of control valves to an open position and determines a speed of the variable speed motor necessary to maintain the pressure of fluid within the plumbing subsystem equal to the set system pressure when each individual control valve is in an open position, and the controller adjusts the speed of the variable speed motor based on which control valves are in the open position.
6. The pumping and water distribution system of claim 5, wherein the controller groups the plurality of control valves into a plurality of groupings and for each grouping determines a speed of the variable speed motor necessary to maintain the pressure of fluid within the plumbing subsystem equal to the set system pressure when each control valve of the grouping is in an open position.
7. The pumping and water distribution system of claim 1, wherein each of the plurality of pool/spa components is assigned a priority value.
8. The pumping and water distribution system of claim 7, wherein the controller determines that a current total flow requirement for a plurality of activated pool/spa components exceeds a flow capacity of the pump and deactivates the pool/spa component having the lowest priority value.
9. The pumping and water distribution system of claim 1, wherein the controller adjusts the speed of the variable speed motor upon one or more of the plurality of the control valves being switched from an open position to a closed position or from a closed position to an open position.
10. The pumping and water distribution system of claim 1, comprising: a pressure sensor, wherein the pressure sensor senses the fluid pressure within the plumbing subsystem and provides a measurement of the sensed fluid pressure to the controller; and a flow meter, wherein the flow meter senses the flow rate of the fluid within the plumbing subsystem and provides a measurement of the sensed fluid flow rate to the controller, wherein the controller adjusts and calibrates each of the plurality of control valves based on the sensed fluid pressure, the sensed fluid flow rate, and a required flow rate of the pool/spa component associated with each respective control valve.
11. The pumping and water distribution system of claim 1, wherein the control valves are manually adjustable and calibratable by a field technician such that each of the control valves provides the specific flow rate of fluid to the associated pool/spa component based on the set system pressure when in the open position.
12. The pumping and water distribution system of claim 1, wherein the plurality of pool/spa components includes a pool/spa jet, an in-floor cleaning system, a water feature, a heater, a filter, a chlorinator, a chemical feeder, a sterilizer, or a pool cleaner.
13. The pumping and water distribution system of claim 1, wherein the pump includes a pump controller and the controller is remote from the pump controller, the controller communicating with the pump controller.
14. The pumping and water distribution system of claim 1, wherein each of the plurality of pool/spa components has a pressure requirement, and the set system pressure is based on the pool/spa component having the highest pressure requirement.
15. The pumping and water distribution system of claim 1, wherein each of the plurality of control valves are individually switchable between the open position and the closed position.
16. The pumping and water distribution system of claim 1, wherein one or more of the plurality of control valves are switchable as a group between the open position and the closed position.
17. A method for controlling a pool or spa pumping system, comprising: receiving information at a controller, the information including a set system pressure and a required flow rate of each of a plurality of pool/spa components; providing a plurality of control valves switchable between an open position and a closed position; associating each of the plurality of control valves with one of the plurality of pool/spa components, and calibrating each of the plurality of control valves based on the information such that each of the plurality of control valves provides a specific flow rate of fluid to the associated pool/spa component based on the set system pressure when in the open

position, each of the plurality of control valves being positioned in a plumbing subsystem between the associated pool/spa component and a pump and controlling the flow of fluid to the associated pool/spa component; and adjusting the speed of a variable speed motor of the pump thereby adjusting a pressure of fluid within the plumbing subsystem to the set system pressure.

18. The method of claim 17, comprising: switching one or more of the plurality of control valves from an open position to a closed position or from a closed position to an open position; and adjusting the speed of the variable speed motor upon the switching of the one or more of the plurality of control valves.

19. The method of claim 17, comprising: sensing a pressure of the fluid within the plumbing subsystem with a pressure sensor; comparing the sensed pressure of the fluid to the set system pressure; determining if the sensed pressure of the fluid is different than the set system pressure; and adjusting the speed of the variable speed motor if it is determined that the sensed pressure of the fluid is different than the set system pressure.

20. The method of claim 17, comprising: sensing a pressure of the fluid within the plumbing subsystem with a pressure sensor; and sensing a flow rate of the fluid within the plumbing subsystem with a flow meter, wherein the calibrating of each of the plurality of control valves is based on the information, the sensed pressure of the fluid within the plumbing subsystem, and the sensed flow rate of the fluid within the plumbing subsystem.

21. The method of claim 17, comprising: switching each of the plurality of control valves to an open position; determining a speed of the variable speed motor necessary to maintain the pressure of fluid within the plumbing subsystem equal to the set system pressure when each individual control valve is in an open position; and adjusting the speed of the variable speed motor based on which control valves are in the open position.

22. The method of claim 17, comprising: grouping the plurality of control valves into a plurality of groupings; switching each of the plurality of control valves of one of the plurality of groupings to an open position; determining a speed of the variable speed motor necessary to maintain the pressure of fluid within the plumbing subsystem equal to the set system pressure when each control valve of the grouping is in an open position; and adjusting the speed of the variable speed motor based on which control valves are in the open position.

23. The method of claim 17, comprising: assigning each of the plurality of pool/spa components a priority value; and deactivating the pool/spa component having the lowest priority value upon determining that a total flow required for a plurality of activated pool/spa components exceeds a flow capacity of the pump.

24. A pumping and water distribution system for a pool or spa, comprising: a pump including a variable speed motor; a controller controlling the speed of the variable speed motor; a plurality of pool/spa components; a plumbing subsystem placing the plurality of pool/spa components in fluidic communication with the pump; and a plurality of control valves switchable between an open position and a closed position, wherein each of the plurality of control valves is associated with one of the plurality of pool/spa components, is positioned in the plumbing subsystem between the associated pool/spa component and the pump, and controls the flow of fluid to the associated pool/spa component, wherein each of the plurality of control valves is calibrated based on a set system pressure and a required flow rate of the associated pool/spa component such that each of the plurality of control valves provides a specific flow rate of fluid to the associated pool/spa component when in the open position, wherein the controller adjusts the speed of the variable speed motor thereby adjusting a pressure of fluid within the plumbing subsystem to the set system pressure, and wherein each of the plurality of pool/spa components is assigned a priority value and the controller determines that a current total flow requirement for a plurality of activated pool/spa components exceeds a flow capacity of the pump and deactivates the pool/spa component having the lowest priority value.

25. A method for controlling a pool or spa pumping system, comprising: receiving information at a

controller, the information including a set system pressure and a required flow rate of each of a plurality of pool/spa components; providing a plurality of control valves switchable between an open position and a closed position; associating each of the plurality of control valves with one of the plurality of pool/spa components based on the information such that each of the plurality of control valves provides a specific flow rate of fluid to the associated pool/spa component based on the set system pressure when in the open position, each of the plurality of control valves being positioned in a plumbing subsystem between the associated pool/spa component and a pump and controlling the flow of fluid to the associated pool/spa component; adjusting the speed of a variable speed motor of the pump thereby adjusting a pressure of fluid within the plumbing subsystem to the set system pressure; assigning each of the plurality of pools/spa components a priority value; and deactivating the pool/spa component having the lowest priority value upon determining that a total flow required for a plurality of activated pool/spa components exceeds a flow capacity of the pump.