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(54) Title: SYSTEM FOR A POOL INCLUDING VISUAL LIGHT COMMUNICATION AND RELATED METHODS

(57) Abstract: A system used to monitor and control a pool using a visual light communication system is disclosed.

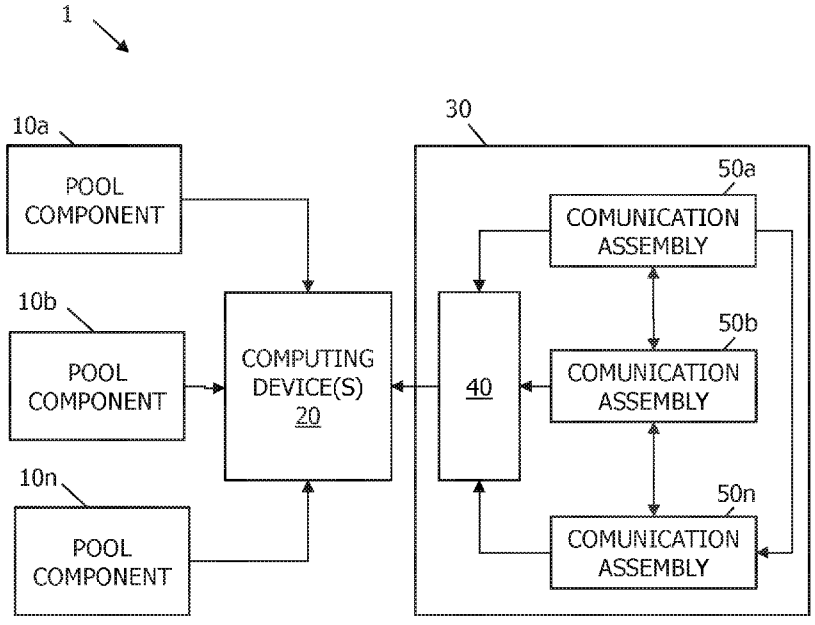

Figure 2

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SYSTEM FOR A POOL INCLUDING VISUAL LIGHT COMMUNICATION AND RELATED METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of and priority to U.S. Provisional Application No. 62/256,491, filed November 17, 2015, U.S. Provisional Application No. 62/256,466, filed November 17, 2015, U.S. Provisional Application No. 62/256,458, filed November 17, 2015, and U.S. Provisional Application No. 62/328,956, filed April 28, 2016, the entire disclosures of which are incorporated by reference into this application for all purposes.

TECHNICAL FIELD

[0002] The present disclosure relates to a system to monitor and control operation of a pool system including pool components, and in particular to such a system that includes a visual light communication system.

BACKGROUND

[0003] Visual light communication (VLC) is a data communication medium that uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as an optical carrier for data transmission and illumination. It uses fast pulses of light to transmit information. Light emitting diodes (LEDs) are one type of light that can be used in VLC. LEDs can be turned on and off quickly and perceived as a continuous beam of light. This is because the reaction time of the typical LED is less than 1 microsecond, which cannot be detected by the human eye. The change from an "on" state to an "off" state in high frequencies enables data transmission. "On" states and "off" states (represented as "1" and "0" respectively) can be encoded as data. Signal processing can be used to process that encoded data into information useable in a variety of contexts.

SUMMARY

[0004] An embodiment of the present disclosure is a visual light communication (VLC) system. The VLC system includes a light transmitter operable in water of a pool system. The light transmitter is configured to repeatedly transition between an on configuration where light is produced and an off configuration where no light is produced in order to generate a light signal that passes through the water. The transmitted light signal has encoded therein information concerning a pool component. The system also includes a light sensor operable within the water

in the pool to receive the transmitted light signal. The light sensor is configured to convert the transmitted light signal into an electronic signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The foregoing summary, as well as the following detailed description of illustrative embodiments of the present application, will be better understood when read in conjunction with the appended drawings. For the purposes of illustrating the present application, there is shown in the drawings illustrative embodiments of the disclosure. It should be understood, however, that the application is not limited to the precise arrangements and instrumentalities shown. In the drawings:

[0006] Figure 1 is a schematic of a pool system according to an embodiment of the present disclosure;

[0007] Figure 2 is a schematic diagram of a system for control and monitoring of the pool system shown in Figure 1;

[0008] Figure 3 is a schematic diagram of a pool component of the pool system shown in Figures 1 and 2;

[0009] Figure 4A is a schematic diagram of computing device according to an embodiment of the present disclosure;

[0010] Figure 4B illustrates a plurality of computing devices networked to communication with the system shown in Figures 1 and 2;

[0011] Figure 5 is a schematic diagram of VLC communication assemblies in the system shown in Figure 2;

[0012] Figures 6 and 7 are schematic diagrams of a portion of the VLC communication system illustrating different signal paths;

[0013] Figure 8 is a perspective view of a VLC assembly according to an embodiment of the present disclosure;

[0014] Figure 9 is a front view of the VLC assembly shown in Figure 8;

[0015] Figure 10 illustrates a side view of the VLC assembly shown in Figures 8 and 9;

[0016] Figure 11 is a process flow diagram illustrating a method for monitoring and controlling the pool system using the VLC system according to an embodiment of the present disclosure;

[0017] Figure 12 is a process flow diagram illustrating a method for monitoring and controlling the pool system using the VLC system according to another embodiment of the present disclosure;

[0018] Figure 13 is a schematic illustrating transmission of pool data among multiple VLC assemblies; and

[0019] Figure 14 is a schematic illustrating scanning of a portion of a pool to monitor and control certain pool components.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0020] There is need to send, receive, process, and contextualize data related to pools. Embodiments of the present disclosure include systems, devices, methods, and software that enable the collection, processing, transmission of information related to various components of a pool system, as water pool water chemistry, flow rates along return lines, pump pressure, etc. It is desirable if this communication system can operate at least in part without hard wiring various sensors and communication components together while still permitting initiate and transmit commands to control various parameters of the pool, such as water circulation, lighting, and chemical balancing, as well as range of other pool and spa system components.

[0021] Figure 1 illustrates a pool system 400 that includes a pump 402, a filter 404, and a valve 406 where conduits from the drain 408 and heater 410 meet. The pool system 400 includes skimmers 412 and 414, a main drain 416, and a plurality of return lines 418 that terminate at returns 420 or return jets. The pump 402 will pull water from the pool 422 through a skimmer 412, 414 or main drain 416. The water is passed through a filter 404, and then filtered water is returned to the pool 422 under pressure through returns 420 and 430 that control flow direction and flow rate. Returns are also referred to as pool jets and are generally mounted on the pool wall below the surface. The return can include pop-up cleaning heads 430 as needed. The water is returned to the pool 422 through the pool jets 420 to create circulation and mixing of the pool water. The pool system may a computing device 20, a communications hub 40, and one or more communication assemblies 50a, 50b, 50c for sending and receiving data concerning the pool 422 and its components.

[0022] Figure 2 illustrates a system 1 for monitoring and controlling operation of the pool system 400. The system 1 includes a plurality of pool components 10a, 10b,…,10n, a computing device 20, a communications system 30 that is in electronic communication with the

computing device 20. In some embodiments, the system 1 may include a plurality of sensors (not shown) coupled to the communications system 30.

[0023] The pool components 10a-10n represent any pool component of a pool system as described above and illustrated in Figure 1. A pool component may be a pump, valves, heater, drain, return lines, pool water, filters, skimmers, pop-up cleaning heads, pool jets, metering device, etc. Each pool component 10a, 10b,... 10n may be in electronic communication with the computing device 20.

[0024] Figure 3 shows schematic diagram of an exemplary pool component 10a. Pool component 10a may include a component sensor 12a, a controller 14a electronically coupled to the sensor 12a, and a send-receive unit 18a electronically coupled to the controller 14a. The component sensor 12a may monitor the pool component and/or obtain pool data from proximate the pool component. The component sensor 12a may communicate with the controller 14a. The communication may be through a physical connection or through a visual light communication, wireless connection, or optionally a wired connection when appropriate. In some embodiments, pool component 10a may include a plurality of component sensors 12a, controllers 14a, and/or send-receive units 18a. In some embodiments, a component sensor 12a may communicate with only one controller 14a, while in alternate embodiments, a component sensor 12a may communicate with a plurality of controllers 14a. Similarly, in some embodiments controller 14a may communicate with only one component sensor 12a, while in other embodiments, controller 14a may communicate with a plurality of component sensors 12a.

[0025] The communications system 30 may include a communication hub 40 and a plurality of communication assemblies 50a-50n. Each communication assembly 50a-50n is electronically connected to the communication hub 40. The communication hub 40 may be electronically connected to the computing device 20 (or multiple computing devices 20). The electronic connection may be a physical connection (e.g. a wire) or it may be a wireless connection (e.g. Wi-Fi, Bluetooth, near field communication, optical, sound, ultrasound, or another wireless connection), or via visual light communication system.

[0026] The communications hub 40 can be any device that connects to a) pool components in the pool system, b) the VLC assemblies, and c) the computing device(s) 20. The communication hub 40 may be a send-receive device that transmits data received from each communication assembly 50a-50n to computing device 20. In some instances, the communication hub 40 may be a component of the computing device 20 such that the computing

device 20 receives the pool data from the communication assemblies 50a-50n. The communication assemblies 50a-50n may be submerged in water and transmits data among the assemblies and to the communications hub 40. The communications hub 40 may be hard-wired or wirelessly connected to the computing device 20. The communication hub 40 allows a user to connect to the pool components, monitor the status of the pool components, and control their operation. A user or pool owner can communicate with pool components of a pool system directly or indirectly via computing device 20. This allows the user or pool owner to control individual pool components by connecting to them directly via the computing device and the VLC assemblies. A user can connect to individual components through the communications hub 40 (Figure 4B), which can be in the form of a central hub. The communication hub can be accessed when the user is in proximity to the pool system. Alternatively, the user can access the communication hub from a remote location. Access to the communication hub is possible via the computing device. Alternatively, the user can access the components of the VLC system associated with the pool components when the user is in proximity to the pool system.

[0027] Referring to Figure 4A, the system 1 may include one computing device 20 and a communications system 30. Figures 4A and 4B illustrate one computing device 20. However, multiple computing devices 20a, 20b, 20c...20n may linked to the communications system 30, as illustrated in Figure 4B. For purposes of clarifying how the software application is implemented across the various computing devices, reference number 20 is used interchangeably with reference numbers 20a, 20b, 20c…, 20n unless noted otherwise. In addition, the present disclosure describes software applications implemented over system components and configured to execute various steps in the methods and techniques described below. It should be appreciated that a software application can implement steps in the methods utilizing all of the system components or just portions of the system components. Furthermore, the software applications are described below in singular form. It should be appreciated that multiple software applications may interface to perform the described functions, and multiple applications can run on more than one computing device to implement the methodologies described herein.

[0028] Turning to Figure 4A, the computing device 20 is configured to receive, process, and store various information used to implement one or more software applications, such as software application 29. The software application 29 may include native instructions for operation of the computing device 20 and instructions for implementing one or more of the methods described below. The hardware components of computing device 20 can include any appropriate device, examples of which include a portable computing device, such as a laptop,

tablet or smart phone, or other computing devices, such as a desktop computing device or a server-computing device.

[0029] As illustrated in Figure 4A, the computing device 20 includes one or more processor 22, a memory 24, input/output elements 26, and a user interface (UI) 28. It is emphasized that the operation diagram depiction of the computing device 20 is exemplary and is not intended to imply a specific implementation and/or configuration. The processor 22, memory 24, input/output portion 26, and user interface 28 can be coupled together to allow communications therebetween, and can interface with the software application 29. The software application 29 may include an application programmatic interface (API).

[0030] Continuing with Figure 4A, the memory 24 can be volatile (such as some types of RAM), non-volatile (such as ROM, flash memory, etc.), or a combination thereof, depending upon the exact configuration and type of processor 22. The computing device 20 can include additional storage (e.g., removable storage and/or non-removable storage) including, but not limited to, tape, flash memory, smart cards, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic storage or other magnetic storage devices, universal serial bus (USB) compatible memory, or any other medium which can be used to store information and which can be accessed by the computing device 20.

[0031] Continuing with Figure 4A, in various embodiments, the input/output portion 26 includes an antenna, lead or trace, electronic connector for wired connection, or a combination thereof. In some implementations, input/output portion 26 can include a receiver and transmitter, transceiver or transmitter-receiver. The input/output portion 26 is capable of receiving and/or providing information concerning components of the pool system. Furthermore, the input/output portion 26 is capable of receiving and/or providing information pertaining to communication with a network such as, for example, the Internet. As should be appreciated, transmit and receive functionality may also be provided by one or more devices external to computing device 20.

[0032] Referring to Figure 4A, the user interface 28, which can include an input device and/or display (input device and display not shown) that allows a user to communicate with the or provide input instructions to the computing device 20. The user interface 28 can include inputs that provide the ability to control the computing device 12, via, for example, buttons, soft keys, a mouse, voice actuated controls, a touch screen, visual cues (e.g., moving a hand in front of a camera), or the like. The user interface 28 can provide outputs, including visual displays of

the data obtained with the detection unit 18. Other outputs can include audio information (e.g., via speaker), mechanically (e.g., via a vibrating mechanism), or a combination thereof. In various configurations, the user interface 28 can include a display, a touch screen, a keyboard, a mouse, an accelerometer, a motion detector, a speaker, a microphone, a camera, or any combination thereof. The user interface 28 can further include any suitable device for inputting biometric information, such as, for example, fingerprint information, retinal information, voice information, and/or facial characteristic information, for instance, so as to require specific biometric information for access to the computing device 20. It should be appreciated that the computer devices can operate via any suitable operating system, such as Android, BSD, iOS, Linux, OS X, QNX, Microsoft Windows, Windows Phone, and IBM z/OS. Furthermore, the software application can operate with any of the aforementioned operation systems.

[0033] Continuing with reference to Figure 4B, the system is implemented via exemplary architecture that includes computing devices 20a, 20b, 20c...,20n in electronic communication with each other via a common communications network, such as, for example the Internet. The computing devices 20a-20n may be connected to a communications hub 40 as further explained below. The computing devices 20a, 20b, 20c... 20n may be arranged in a client-server architecture. The computing device 20a can receive and transmit data to other computing devices 20b, 20c,...20n. In addition, one up to all the computing devices can receive information from the other computing devices. Furthermore, one or all of the computing devices can access information on the other computing devices. "Access" or "accessing" as used herein can include retrieving information stored in memory on a computing device. For instance, "access" or "accessing" includes sending instructions via the network to computing device 20a so as to cause information to be transmitted to the memory of the computing device 20b for access locally by the computing device 20b. In addition or alternatively, "access" or "accessing" can include the sending of an instruction to/from one computing device to access information stored in the memory on another computing device.

[0034] Figure 4B illustrates a client-server network. However, the software application (s) can be implemented over any number of network configurations. For example, in alternate embodiments, the computing devices 20a, 20b, 20c...20n are configured as a peer-to-peer network architecture. In still other alternative embodiments, the computing devices 20a, 20b, 20c...20n can be arranged in a ring-type network architecture. Further, the software applications can be implemented across computing devices arranged on a network that includes aspects of a client-server network, peer-to-peer network, ring-type network, and/or other network

architectures known to a person of ordinary skill in the art. Accordingly, it should be appreciated that numerous suitable alternative communication architectures are envisioned.

[0035] Figure 5 shows an embodiment communication system 30 implemented using visual light communication assemblies 50a and 50b. The communication system 30 includes a first visual light communication (VLC) assembly 50a and a second visual light communication (VLC) assembly 50b positioned across a water gap W. The first visual light communication (VLC) assembly 50a includes a light transmitter 52a, a light sensor-receiver 54a, a communication assembly controller 56a, and a power source 58a. The light transmitter 52a may communicate with a sensor receiver 54a in the first VLC assembly 50a and with a sensor-receiver 54b in the second VLC assembly 50b.

[0036] The light transmitter 52a can be an LED on one side of a water gap W and the sensor-receiver 54b can be a photo diode on the other side of a water gap W. The light transmitter 52a is configured to repeatedly transition between an on configuration where a light is produced and an off configuration where no light is produced. The repeated transitions between the on and off configurations generate a transmitted light signal having encoded therein information concerning a pool component of a pool system. The sensor-receiver 54a is configured to receive the transmitted light signal from a different transmitter.

[0037] In accordance with the illustrated embodiment, the light transmitter 52a can be a high-brightness white LED. The sensor-receiver 54a can be a silicon photodiode that is responsive to a visible wavelength. The sensor-receiver is configured to function as a receiving element. Embodiments of the present disclosure allow for using mixtures of red, green, and blue LEDs to provide the opportunity to alter the light frequency encoding to a different data channel. In one example, data files of at least 256K have been transmitted up to 10 meters through turbid water with minimal data loss. This data point is not limiting but is illustrative. Data files may be transmitted more than 10 meters with minimal data loss. The system as described herein may be to retrofit pre-existing LED lighting systems to allow for simple interactive functional commands between lights. These commands can be read by a computing device in proximity to the LEDs. Alternatively, the commands can be transmitted remotely via wireless communication channels.

[0038] The controller 56a is electronically coupled to the transmitter 52a and the receiver 54a. The power source 58a supplies power to the controller 56a, the transmitter 52a, and the receiver 54a. The controller 56a may include an encoder 57a and a modulator-demodulator 59a (and/or demodulator-modulator 59a). The controller 56a may include signal

processing instructions, firmware, communication protocols, and/or other applications that operate signal transmission between the transmitter 52a and the receiver 54a and between different communication assemblies. The communication assembly 50a may include a plurality of transmitters 52a, receivers 54a, power sources 58a, and/or communication assembly controllers 56a. Furthermore, the transmitter 52a and receiver 54a can be configured as a transceiver, a transmitter-receiver, or any other device for processing input and output signals. In such an example, the transmitter is configured to switch the light source on and off in order to generate a signal having encoding therein data.

[0039] The first VLC assembly 50a includes a power source 58a. A number of different power sources 58a may be used. For instance, the power source 58a can be batteries or power generators. For example, the power generators can be flutter type that include a body configured to oscillate or move in response to fluid flow and generate a voltage based on said oscillations. In another example, the power generator can be a body with an inner surface, an outer surface, a winding at least partially disposed along the outer surface, a passage, and a moveable element disposed in the passage and moveable relative to the body so as to generate a voltage in response to fluid flow through the body.

[0040] The second visual light communication (VLC) assembly 50b includes a light transmitter 52b, a light sensor-receiver 54b, a communication assembly controller 56b, and a power source 58b. The light transmitter 52b may communicate with a sensor receiver 54b and with a sensor-receiver 54a in the first VLC assembly 50a. The light transmitter 52b can be an LED on one side of a water gap W and the sensor-receiver 54a can be a photo diode on the other side of a water gap W. The controller 56b is electronically coupled to the transmitter 52b and the receiver 54b. The power source 58b supplies power to the controller 56b, the transmitter 52b, and the receiver 54b. The controller 56b may include an encoder 57b and a modulator-demodulator 59b (and/or demodulator-modulator 59b). The controller 56b may include signal processing instructions, firmware, communication protocols, and/or other applications that operate signal transmission between the transmitter 52b and the receiver 54b and between with other communication assemblies 50a. The second VLC assembly 50b may include a plurality of transmitters 52b, receivers 54b, power sources 58b, and/or communication assembly controllers 56a. Furthermore, the transmitter 52b and receiver 54b can be configured as transceiver, a transmitter-receiver, or any other device for processing input and output signals. In such an example, the transmitter is configured to switch the light source on and off in order to generate a signal having encoding therein data.

[0041] The second VLC assembly 50b includes a power source 58b. The power source 58b can be batteries or power generators. For example, the power generators can be be-flutter type that include body configured to oscillate or move in response to fluid flow and generate a voltage based on said oscillations. In another example, the power generator can be a body with an inner surface, an outer surface, winding at least partially disposed along the outer surface, a passage, a moveable element disposed in the passage and moveable relative to the body so as to generator a voltage in response to fluid flow through the body.

[0042] Continuing with Figure 5, in operation data is transmitted via a light transmitter 52a into pool water W in the form of a light signal S1. The light signal S1 passes through an optional lens (not shown) covering into the water W until it reaches anther optional lens (not shown) covering the sensor-receiver 54b in the second VLC assembly 50b. The received light signal is converted back into data and sent to the communications hub 40 and relayed to the computing device 20 for further processing. Furthermore, data may be transmitted via a light transmitter 52b of the second VLC assembly 50b in the form a light signal S2 to the sensor-receiver 54a of the first VLC assembly 50a. The received light signal S2 is converted back into data and sent to the communications hub 40 and relayed to the computing device 20 for further processing. The light transmitters 52a and 52b and sensor-receivers 54a and 54b can be communication with each other. Furthermore, each light transmitter 52a, 52b,... 52n may be configured to emit a signal at a defined transmission angle. Each sensor-receiver 54a, 54b,... 54n may be configured to emit a signal at a defined transmission angle that is wider than the transmission angle of the light transmitter 52a, 52b,... 52n. This feature can maximize the ability of multiple sensor-receivers to capture a light signal regardless of the alignment of the light transmitter and the sensor-receiver within the water gap W.

[0043] Figures 6 and 7 illustrate alternative configurations for implementing visual light communications in a pool environment. In the illustrated embodiment Figure 6, data is encoded and modulated via the controller 56a before being sent to light transmitter 52a. Furthermore, the light transmitter 52a may have different color transmitters, such as a red transmitter 62, a green light transmitter 64, and a blue light transmitter 66. The signal is received by the sensor-receiver 54b in Figure 6. The signal is then decoded and demodulated in controller 56b. Alternatively, as shown in Figure 7, each sensor-receiver 54b has sensors 72, 74, and 76 that correspond to the different light transmitters 62, 64, and 66. The data can be encoded and modulated via the controller 56a and then split among the different light transmitters 62, 64, and 66 as shown in Figure 6. Alternatively, the signal can be parsed into groups before being

encoded and modulated. Upon receiving the signal by the sensor receiver 54b, the signal may be demodulated and decoded via controller 56b. Each signal group is then transmitted from a separate light transmitter. Accordingly, the sensor-receivers receive each signal group and decode and demodulate each group separately before re-combining the groups together to re-form the entirety of the transmitted information.

[0044] The VLC communication assemblies described here are configured as send-receive assembles. Each send-receive assembly, or VLC assembly, therefore includes the at least one light transmitter and at least one sensor. Each VLC assembly is configured to A) transmit a respective transmitted light signal, and B) receive a respective one of the transmitted light signals from a different one of the plurality of send-receive assemblies. The VLC assembly may be disposed along one or more of the pool system components. Alternatively, the VLC assembly may include a light transmitter and another VLC assembly may include a sensor-receiver such that individual VLC assemblies are configured for send functions or received functions.

[0045] Figures 8-10 illustrate an exemplary hardware implementation of the VLC assembly 50a, 50b. The VLC assembly 50a may include a housing 90 having a first portal 92 that contains the transmitter 52a and a second portal 94 for the sensor-receiver 54a. The light transmitters 52a may include a red transmitter 62, a green light transmitter 64, and a blue light transmitter 66, and a lens 92. The sensor-receiver 54a includes multiple photo-diodes and a lens 94. Within the housing 90 is a PCB 96 including circuitry, the controller 56a, and power source 58a. The housing 90 may be adapted to couple to a pool system component, such as return line or nozzle and the like.

[0046] Figure 11 illustrates a method 700 of using the visual light communication among one or more pool components. The method 700 may be implemented using computing device 20 and one or more VLC assemblies 50a, 50b...50n. As shown in Figure 11, in step 702, pool data is obtained for example via sensor or other monitoring device. In step 706, the light transmitter 52a transmits the light signal within pool water. Step 706 may include signal processing, such as encoding and modulation of the data into the light signal. In step 708, the sensor-receiver 54b of a second VLC assembly, also submerged in water, receives the transmitted light signal through the pool water. However, in step 710, the signal transmitted in step 706 may be received by multiple VLC assemblies. In step 712, the transmitted light signal can be relayed to the communications hub 40. The communications hub 40 may include a receiver submerged in water so as to receive signals from the VLC assemblies 50a, 50b under water. Other components of the communications hub 40 relay the pool data to the computing

device 20. Accordingly, methods described herein are suitable for communication from an underwater communication to a location that is external to the pool water, as described above. Examples include, but are not limited to, direct water-to-air communication, and/or indirect water-to-air communication. The system may include a VLC system as described above and one or other communications systems or protocols to enable data collected within the pool to be transmitted to a computing device external to the pool. Furthermore, the systems as described herein can be used to transmit inputs, commands, or control instructions from a computing device external to the pool system to parts of the VLC system and/or a computing device associated with the VLC and the pool components. Accordingly, for signals traveling between two non-similar fluids, the transmission is not hindered.

[0047] The VLC assemblies in method 700 may transmit data at different speeds. In one embodiment, uploading and processing a signal using VLC creates no significant lag, resulting in substantially instantaneous transmission and analysis. In a further embodiment, uploading and processing analog or digital signaling using indirect VLC and adaptive modulation may incur a time lag, thus not being substantially instantaneous. An advantage of such an embodiment is use in data transmission that is not highly time-dependent. This may decrease costs associated with using such an embodiment, for example manufacturing costs, installation costs, and operation costs. Such an embodiment may be well-suited for use in swimming pools or similar environments.

[0048] Continuing with Figure 11, in step 716, the computing device 20 can adjust operation of a pool system component. For instance, step 716 may include causing, via the computing device, a mechanical or electrical action of at least one of the plurality of pool components in response to information encoded in the transmitted light signal. A mechanical response may be movement or transition of a state of one or more pool components. Electrical responses may include processing, powering up, powering down, etc.

[0049] Embodiments of the present disclosure are suitable for controlling operation or monitoring the state of one or more pool components of a pool system. An exemplary method 800 for monitoring and controlling a pool system is shown in Figure 12. The pool components may include, but are not limited to, a water pump, return lines, return fitting, return jets, , pool filter, motor, skimmer, and pool lighting, a chemistry analyzer. Embodiments of the present disclosure include a system that has the ability to communicate certain data regarding conditions including, but not limited to, temperature, chemistries, flow rates, and pressures. An embodiment may also be configured to initiate and transmit commands to control different

aspects of the pool system environment, including, but not limited to, fluid circulation, lighting, and chemical balancing.

[0050] Referring to Figure 12, step 802 of the method 800 includes obtaining data for one or more of the pool system components. Step 806 includes transmitting pool data via a VLC assembly, at least a portion of which is in pool water. Step 808 includes transmitting the compiled information concerning the one or more of the pool system components to a computing device. The method can further include in step 812 analyzing the information concerning the one or more pool system components. Step 816 includes displaying the information concerning one or more of the pool system components on a user interface running on the computing device. In step 816, the computing device 20 can adjust operation of a pool system component in response to an instruction from the computing device to alter the state the pool system component.

[0051] Referring to Figure 13, embodiments of the present disclosure have VLC assemblies with functionality that allows for receiving and processing signals within water in a variety of pool layouts and configurations. The VLC assemblies are configured to transmit, receive, and analyze data from refracted or scattered light. An advantage of such an embodiment is that the light transmitter can be directed at the sensor-receiver at larger angles. For instance, as illustrated in Figure 13, a light transmitter of a first VLC assembly 50a can be positioned along a common axis A1 that is directly across from a sensor-receiver of the second VCL assembly 50b. The light transmitter 52a of first VLC assembly 50a can be positioned at location that is offset from the sensor-receiver of a third VLC assembly 50c aligned along an axis A2. Furthermore, each light transmitter 52a, 52b,... 52n may be configured to emit a signal at a defined transmission angle α. Each sensor-receiver 54a, 54b,... 54n may be configured to emit a signal at a defined transmission angle αr that is wider than the transmission angle αt of the light transmitter 52a, 52b,... 52n. This feature can maximize the ability of multiple sensor-receivers to capture a light signal regardless of the alignment of the light transmitter and the sensor-receiver within the water gap W. Thus, data transmission can occur regardless of whether the light transmitter and the sensor-receiver are positioned along a direct, linear path with respect to each other or if they are not positioned along a direct, linear path.

[0052] An embodiment of the present disclosure may have a program or application that allows a user to select which pool component to monitor and control. The program can utilize any suitable method of selecting a pool component or set of pool components. For

example, the user may select the desired component from a displayed list or grid of components. The components can be displayed in any suitable layout.

[0053] In one example as shown in Figure 14, the user may point an imaging device connected to a computing device 40 to a portion P of pool 422. The computing device 422 can then obtain information concerning pool components within that portion P of the pool 422 and display their status on the computing device's user interface. Alternatively, the user can select a pool component based on proximity to the computing device 20 being used. For example, if the computing device 20 is within a predetermined vicinity of the return 10c, the computing device can display the return 10c and status information regarding the return 10c. If the user would like to control operation of the return 10c, the user interface displays control inputs that can be used to control one or more operation of the return 10c. Alternatively, any other acceptable method of selecting a component from a group of components can be utilized in the program or application.

[0054] Embodiments of the present disclosure may include a system that can react to changes that occur within the pool environment. Examples of automated control of pool components include, but are not limited to, lighting, heating, surface skimming, pump activation, and drain valve activation. Such a system could react to various stimuli, such as, for example, the presence of users in the pool, the chemical analysis of the water, presence of a foreign object, and other internal or external environmental factors.

[0055] Data communication with the use of VLC can be affected by various factors. These factors may include, but are not limited to, light wavelength attenuation and absorption, turbidity of the fluid medium, motion on the surface of the fluid, chemical composition in the fluid and interaction of the chemical components, presence of bubbles or particulates in the medium, transition of the signal from water-to-air or air-to-water, reflection or refraction of light in the fluid, and the maximum range of the light transmitter components. Other factors may include, but are not limited to, placement of light-emitters and light-receivers with respect to one another, internal or external power sources for operating the components, levels of signal noise, conversion of analog-to-digital or digital-to-analog signals, underwater and above water signal processing components, the presence of a time lag in transmitting, receiving and analyzing signals, and external controls (such as computers or smartphones). Embodiments of the present disclosure include different variations intended to address one or more of the above-mentioned factors to facilitate acquisition, processing, and use of pool data.

[0056] Embodiments of the present disclosure also include the ability of a pool communication system as described in any of the above embodiments to interact with components already present in the pool system, such as lights, pumps, drains, valves, heaters, vacuums, and all other components common to swimming pool use and maintenance. A further embodiment also has the ability of the pool communication system to interact with external components not within a pool system. For example, the VLC system in a pool may interact with external components in a nearby building or vehicle.

[0057] While the foregoing description and drawings represent the various exemplary embodiments of the present disclosure, it will be understood that various additions, modifications, combinations and/or substitutions may be made therein without departing from the spirit and scope of the invention as defined in the accompanying claims. In particular, it will be clear to those skilled in the art that the invention may be embodied in other specific forms, structures, arrangements, proportions, and with other elements, materials, and components, without departing from the spirit or essential characteristics thereof. In addition, features described herein may be used singularly or in combination with other features. For example, features described in connection with one embodiment may be used and/or interchanged with features described in another embodiment. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and not limited to the foregoing description.

CLAIMS:

1. A visual light communication (VLC) system for a pool system, the VLC system comprising:

a light transmitter operable in water of the pool system, the light transmitter configured to repeatedly transition between an on configuration where light is produced and an off configuration where no light is produced in order to generate a light signal that passes through the water, and the transmitted light signal has encoded therein information concerning a pool system component; and

a light sensor operable within the water in the pool to receive the transmitted light signal, wherein the light sensor is configured to convert the transmitted light signal into an electronic signal.

2. The visual light communication system of claim 1, wherein the at least one sensor is a photodiode.

3. The visual light communication system of claim 1, wherein the light transmitter is a light emitting diode.

4. The visual light communication system of claim 1, further comprising a send-receive assembly, wherein the send-receive assembly includes the light transmitter and at least one sensor.

5. The visual light communication system of claim 1, further comprising a plurality of the send-receive assemblies, wherein each send-receive assembly is configured to transmit a respective transmitted light signal and to receive a respective one of the transmitted light signals from a different one of the plurality of send-receive assemblies.

6. The visual light communication system of claim 1, wherein the send-receive assembly is disposed along one or more of the pool system components.

7. The visual light communication system of claim 1, wherein the light transmitter is disposed along one or more of the pool system components.

8. The visual light communication system of claim 1, wherein the light sensor is disposed along one or more of the pool system components.

9. The visual light communication system of claim 1, wherein the pool system component is one or more of a water pump, return lines, return fitting, return jets, maintenance systems, pool

water, pool filter, motor, skimmer, pool lighting, heating, sensors, and automated chemistry control.

10. The visual light communication system of claim 1, further comprising a computing device configured to process information concerning the pool system component.

11. The visual light communication system of claim 1, further comprising a computing device configured to display information concerning the pool system component.

12. The visual light communication system of claim 1, wherein the transmitted light signal is within the visual spectrum.

13. The visual light communication system of claim 1, wherein the transmitted light signal is not within the visual spectrum.

14. A method of using the visual light communication according to any one of the claims 1 to 14, further comprising the steps of:

transmitting the light signal; and

receiving the transmitted light signal through a fluid.

15. The method of visual light communication according to claim 14, further comprising displaying information concerning the pool system component.

16. The method of visual light communication according to claim 14, further comprising causing a mechanical or electrical action of one or more of the pool system components in response to receiving the transmitted light signal.

17. The method of visual light communication according to claim 16, wherein the mechanical or electrical action is moving a return jet.

18. The method of visual light communication according to claim 16, wherein the mechanical or electrical action is operating a pump.

19. The method of visual light communication according to claim 16, wherein the mechanical or electrical action is analyzing a chemical composition of pool water.

20. A method for monitoring a pool system, comprising:

compiling information for one or more of the pool system components via a visual light communication system at least a portion of which is in pool water; and

transmitting the compiled information concerning the one or more of the pool system components to a computing device.

21. The method of claim 20, further comprising the step of processing the information concerning the one or more pool system components.

22. The method of claim 20, further displaying the information concerning one or more of the pool system components on the computing device.

23. The method of claim 20, processing an instruction from the computing device to alter the state of one or more of the pool system components.

24. The method according to any one of the claims 20 to 23, wherein the one or more of the pool system components is one or more of a water pump, return lines, return fitting, return jets, maintenance systems, pool water, pool filter, motor, skimmer, pool lighting, heating, sensors, and automated chemistry control.

25. A pool jet fitting include a moveable nozzle assembly that is configured to move in response to the transmitted light signal of claims 1 to 24.

26. The pool jet fitting of claim 25, wherein the moveable nozzle assembly is configured transition between an open configuration and a closed configuration in response to the transmitted light signal without requiring flow to induce movement between the open and closed positions.

27. The pool jet fitting of claim 25, wherein the moveable nozzle assembly is configured to rotate as it transitions between the open configuration and the closed configuration.

28. A system to monitor and control operation of a pool system including a plurality of pool components, comprising:

a visual light communication system that includes a) at least one light transmitter configured to repeatedly transition between an on configuration where light is produced and an off configuration where no light is produced in order to generate a transmitted light signal having encoded therein information concerning at least one of the plurality of pool components, and b) at least one sensor configured to receive the transmitted light signal and convert the transmitted light signal into an electronic signal; and

at least one computing device configured to control at least one of the plurality of pool components based on the information concerning the at least one of the plurality of pool components encoded in the transmitted light signal.

29. The system of claim 28, wherein the at least one sensor is configured to receive the transmitted light signal through a fluid.

30. The system of claim 28, wherein the at least one light transmitter is operable underwater, and the at least one sensor is operable underwater.

31. The system of claim 28, wherein the at least one light transmitter is at least one light emitting diode, and the at least one sensor is a photodiode.

32. The system of claim 28, wherein the at least one light transmitter is associated with the at least one of the plurality of pool components.

33. The system of claim 32, wherein the at least one sensor is associated with the at least one of the plurality of pool components.

34. The system of claim 28, wherein the at least one light transmitter is a plurality of light transmitters, and the at least one sensor is a plurality of sensors, wherein a respective one of the plurality of light transmitters and a respective one of plurality of sensors are each configured to be associated with a respective one the plurality of pool components.

35. The system of claim 28, further comprising a send-receive assembly that includes the at least one light transmitter and the at least one sensor.

36. The system of claim 35, further comprising a plurality of send-receive assemblies, wherein each send-receive assembly is configured to a) transmit the transmitted light signal and b) receive the transmitted light signal from a different one of the plurality of send-receive assemblies.

37. The system of claim 36, wherein each pool component includes one of the plurality of send-receive assemblies.

38. The system of claim 28, wherein the plurality of pool components include at least one of a water pump, a return line, a return fitting, a return jet, a maintenance system, a pool filter, a motor, a skimmer, a pool lighting assembly, a pool heater, and an automated pool chemistry computing device.

39. The system of claim 28, wherein the transmitted light signal is within the visual spectrum.

40. The system of claim 28, wherein the transmitted light signal is not within the visual spectrum.

41. The system of claim 28, wherein the at least one light transmitter is a red light transmitter.

42. The system of claim 28, wherein the at least one light transmitter is a green light transmitter.

43. The system of claim 28, wherein the at least one light transmitter is a blue light transmitter.

44. The system of claim 28, wherein the at least one light transmitter is a plurality of light transmitters, and wherein each light transmitter is operable to transmit a different colored light signal.

45. The system of claim 28, wherein the at least one light transmitter is a plurality of light transmitters, and wherein each light transmitter is operable to transmit a different wavelength of light.

46. The system of claim 28, wherein the at least one sensor are configured to be positioned directly across from the at least one light transmitter along an axis.

47. The system of claim 28, wherein the at least one light transmitter defines a transmission axis, and wherein the at least one sensor is configured to receive the transmitted light signal emitted by the at least one light transmitter from a direction that angularly offset with respect to the transmission axis.

48. The system of claim 28, wherein the at least one sensor is configured to receive a refracted transmitted light signal emitted by the at least one light transmitter.

49. The system of claim 28, wherein the at least one computing device is configured to control an operation of one or more of the plurality of pool components based on presence of a foreign object in the pool system.

50. The system of claim 28, wherein the at least one computing device is configured to analyze a chemical composition of water in the pool system based on measurements obtained by a water sensor that in configured to be in communication with the visual light communication system.

51. The system of claim 28, wherein the at least one computing device is configured to a) process the information concerning a state of the at least one pool component of the plurality of pool components, and b) based on the information concerning the state of the at least one pool component of the plurality of pool components, send a control command to the at least one pool

component of the plurality of pool components via the visual light communication system, the control command causing an operation of the at least one of the plurality of pool components.

52. The system of claim 28, wherein the at least one computing device is external to water in the pool system and the at least one light transmitter and the at least one sensor are each inside the water.

53. The system of claim 28, wherein the at least one computing device is a controller, wherein the controller is configured to operate at least one of the plurality of pool components.

54. The system of claim 28, wherein the at least one computing device is configured to be in communication with each light transmitter and each sensor.

55. The system of claim 54, further comprising a communications module that is configured to be in communication with the at least one light transmitter, the at least one sensor, and the at least on computing device.

56. The system of claim 55, wherein the at least one light transmitter is a plurality of light transmitters, and the at least one sensor is a plurality of sensors, and the at least one computing device is a plurality of computing devices.

57. The system of claim 55, wherein the at least one computing device is configured to be in communication with the at least one light transmitter and the at least one sensor via a wireless connection or a wired connection.

58. The system of claim 55, wherein the communications module is a communication hub configured to be in communication with 1) the at least one light transmitter, 2) the at least one sensor, 3) the at least one computing device, and 4) the at least one pool component of the plurality of pool components.

59. The system of claim 28, wherein the at least one computing device is a tablet.

60. The system of claim 28, wherein the at least one computing device is smartphone

61. The system of claim 28, wherein the at least one computing device is a wearable computing device.

62. The system of claim 28, wherein the at least one computing device is a controller configured to operate one or more of the plurality of pool components.

63. The system of claim 28, wherein the computing device is configured to enable communication with the at least one pool component of the plurality of pool components of the

plurality of pool components when the computing device is within a predetermined vicinity of the at least one pool component of the plurality of pool components.

64. The system of claim 63, wherein the at least one computing device is configured to, in response to an input on a user interface running on the computing device, obtain the information concerning the at least one pool component of the plurality of pool components via the visual light communication system.

65. The system of claim 63, wherein a user interface running on the computing device enables inputs concerning the at least one pool component of the plurality of pool components to be transmitted to the at least one computing device when the computing device is within the predetermined vicinity.

66. The system of claim 28, wherein the computing device includes a visual sensing device, the visual sensing device define a viewing range, wherein the computing device is configured to enable communication with the at least one pool component of the plurality of pool components when the at least one pool component of the plurality of pool components is within the viewing range of the visual sensing device of the computing device.

67. The system of claim 66, wherein the visual sensing device is a camera.

68. The system of claim 66, wherein the computing device is configured to cause an image of a pool to be displayed on the user interface when the visual sensing device is oriented toward the pool.

69. The system of claim 68, wherein the computing device is configured to, in response to an input on the user interface running on the computing device, obtain the information concerning the at least one of the plurality of pool components within a portion of the pool captured in the image of the pool displayed on the computing device.

70. The system of claim 63, wherein the at least one pool component of the plurality of pool components is configured to transmit a signal that is detectable by the computing device when the computing device is within the predetermined vicinity.

71. The system of claim 63, wherein the computing device is configured to display a status of the at least one pool component of the plurality of pool components.

72. The system of claim 63, wherein the computing device is configured to control operation of the at least one pool component of the plurality of pool components.

73. The system of claim 28, wherein the at least one computing device is configured to utilize adaptive modulation to process the transmitted light signal.

74. A method of for monitoring a pool system, the method comprising:

capturing an image of a portion of a pool with a computing device;

displaying the portion of the pool on a user interface running on the computing device;

receiving an input indicative of a sector of the portion of the pool displayed on the computing device, wherein the sector includes at least one of a plurality of pool components of the pool system;

sending an instruction to one or more receivers within the sector of the portion of the pool, the instruction, when executed by a processor, causes the status of the at least one of the plurality of pool components within the sector of the portion of the pool captured in the image to be transmitted to the computing device; and

displaying via the user interface the status of the at least one of the plurality of pool components within the sector of the portion of the pool scanned by the computing device.

75. The method of claim 74, further comprising detecting one or more conditions of the at least one of the plurality of pool components via one or more sensors that in communication with the one or more receivers.

76. The method of claim 75, further comprising transmitting information indicative of one or more conditions of the at least one of the plurality of pool components to a computing device via a visual light communication system.

77. The method of claim 76, wherein the visual light communication system includes a) at least one light transmitter configured to repeatedly transition between an on configuration where a light is produced and an off configuration where no light is produced, such that the repeated transitions between the on and off configurations generate a transmitted light signal having encoded therein information concerning at least one of the plurality of pool components, and b) at least one sensor configured to receive the transmitted light signal.

78. A communication system for a pool having a plurality of pool components, the communication system comprising:

an underwater visual light communications module that includes a) at least one light transmitter configured to repeatedly transition between an on configuration where a light is

produced and an off configuration where no light is produced, such that the repeated transitions between the on and off configurations generate a transmitted light signal having encoded therein information concerning a pool system component, and b) at least one sensor configured to receive the transmitted light signal; and

at least one communication module in electronic communication with the underwater visual light communications module, the at least one communication module configured to receive a signal that is indicative of the information concerning one or more of the plurality of pool components, wherein the at least one communication module is configured to transmit information concerning a pool system component to a computing device.

79. The communication system of claim 78, wherein the at least one communication module is configured to transmit the signal to the computing device through water.

80. The communication system of claim 78, wherein the at least one communication module is configured to transmit the signal to the computing device via wired connection.

81. The communication system of claim 78, wherein the at least one communication module is configured to transmit the signal to the computing device via wireless connection.

82. The communication system of claim 78, wherein the at least one sensor is configured to receive the transmitted light signal through water.

83. The communication system of claim 78, wherein the at least one light transmitter is at least one light emitting diode.

84. The communication system of claim 78, further comprising a send-receive assembly, wherein the send-receive assembly includes the at least one light transmitter and the at least one sensor.

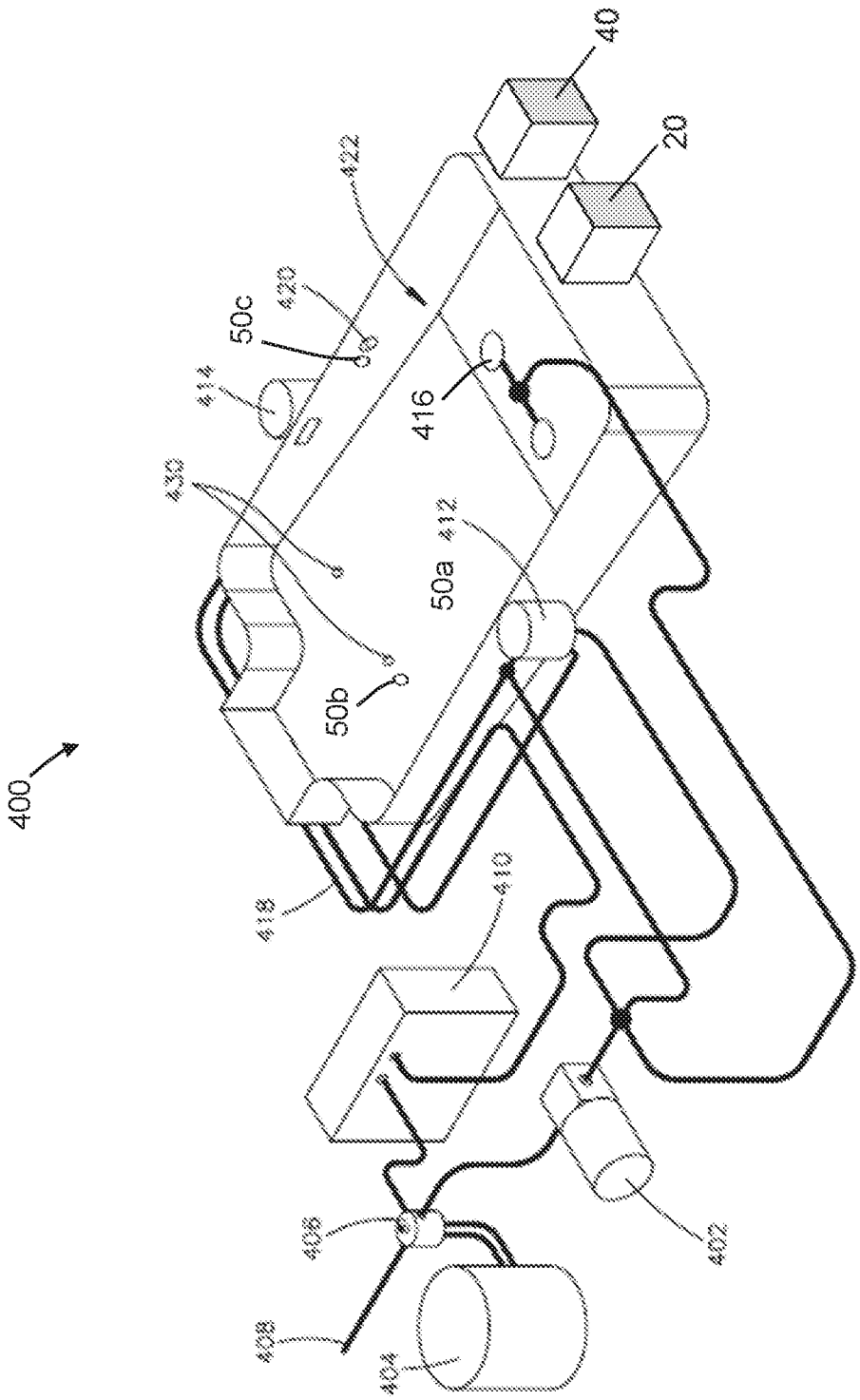
400
40
20
422
420
50c
414
416
430
412
50a
50b
418
410
408
428
404
402

Figure 1

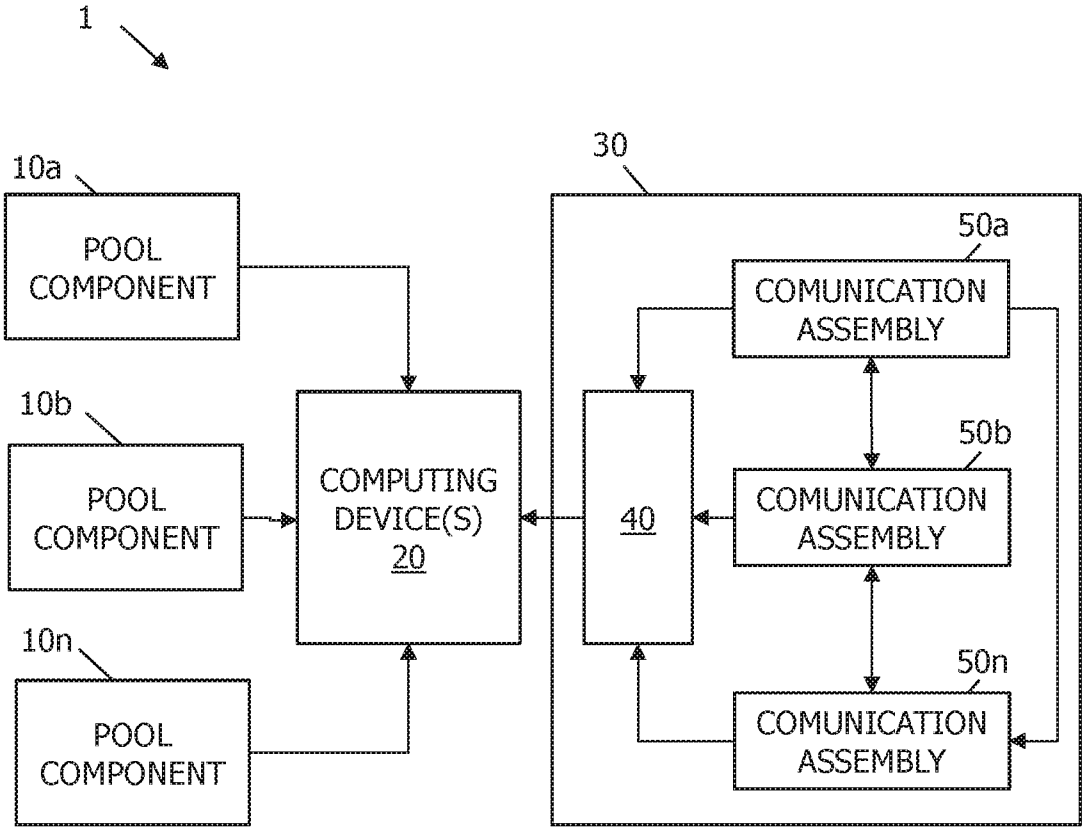

Figure 2

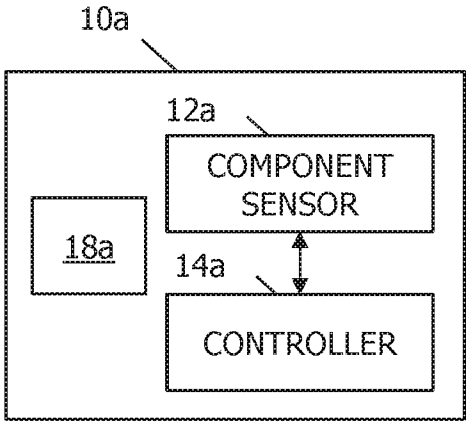

Figure 3

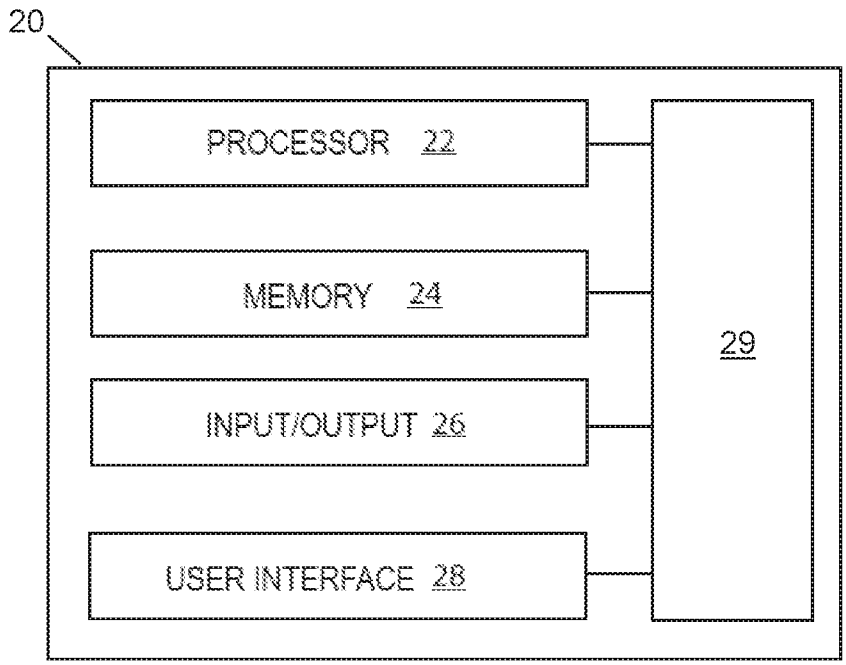

Figure 4A

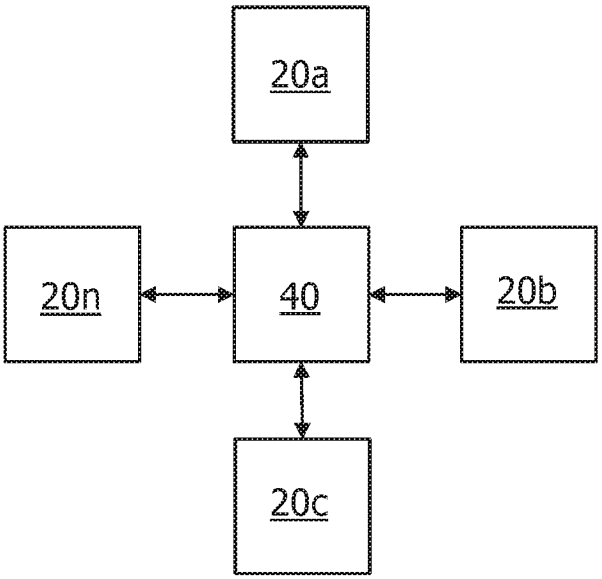

Figure 4B

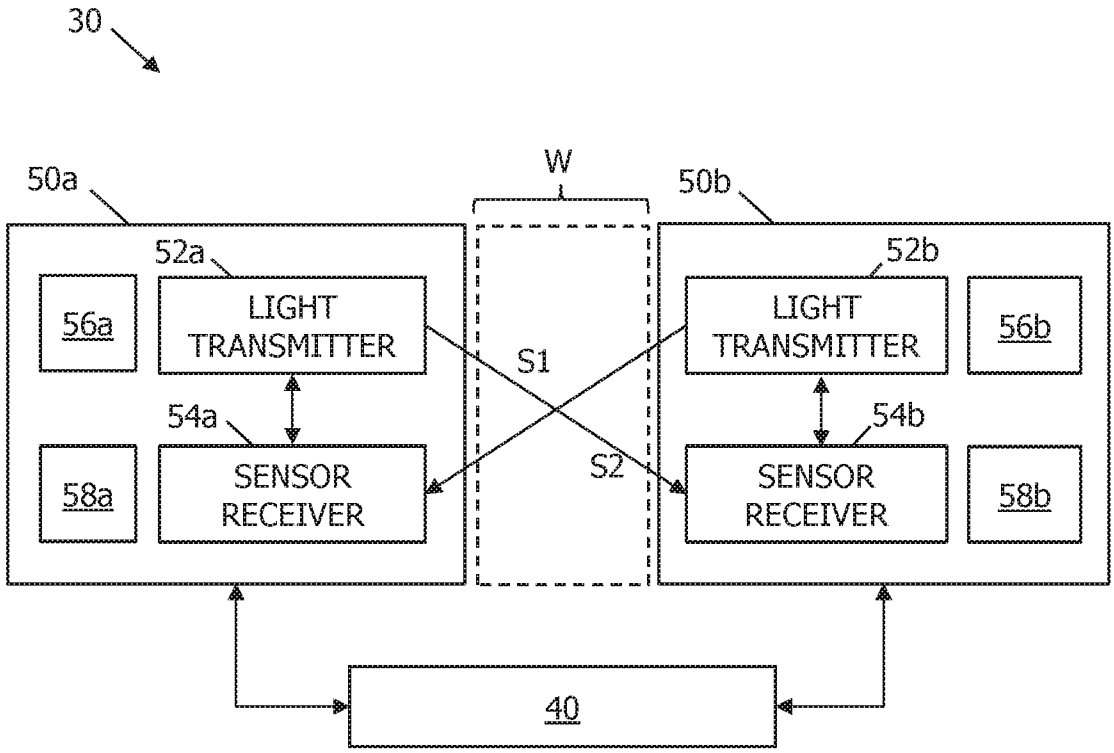
30
50a
W
50b
52a
52b
56a
LIGHT TRANSMITTER
S1
LIGHT TRANSMITTER
56b
54a
54b
58a
SENSOR RECEIVER
S2
SENSOR RECEIVER
58b
40

Figure 5

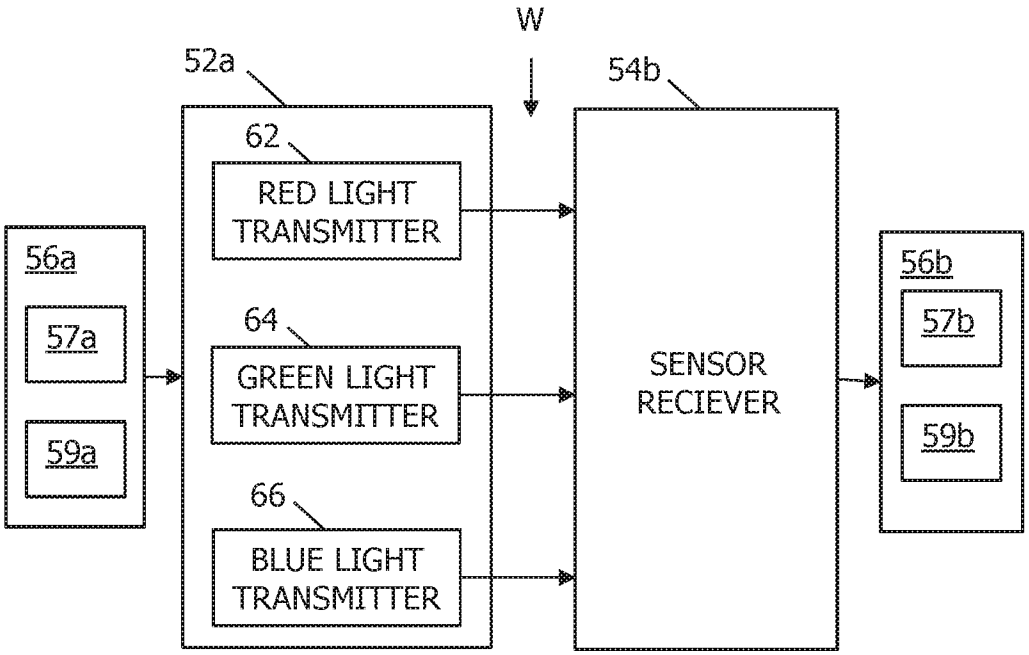
W
52a
54b
62
RED LIGHT TRANSMITTER
64
GREEN LIGHT TRANSMITTER
66
BLUE LIGHT TRANSMITTER
56a
57a
59a
SENSOR RECIEVER
56b
57b
59b

Figure 6

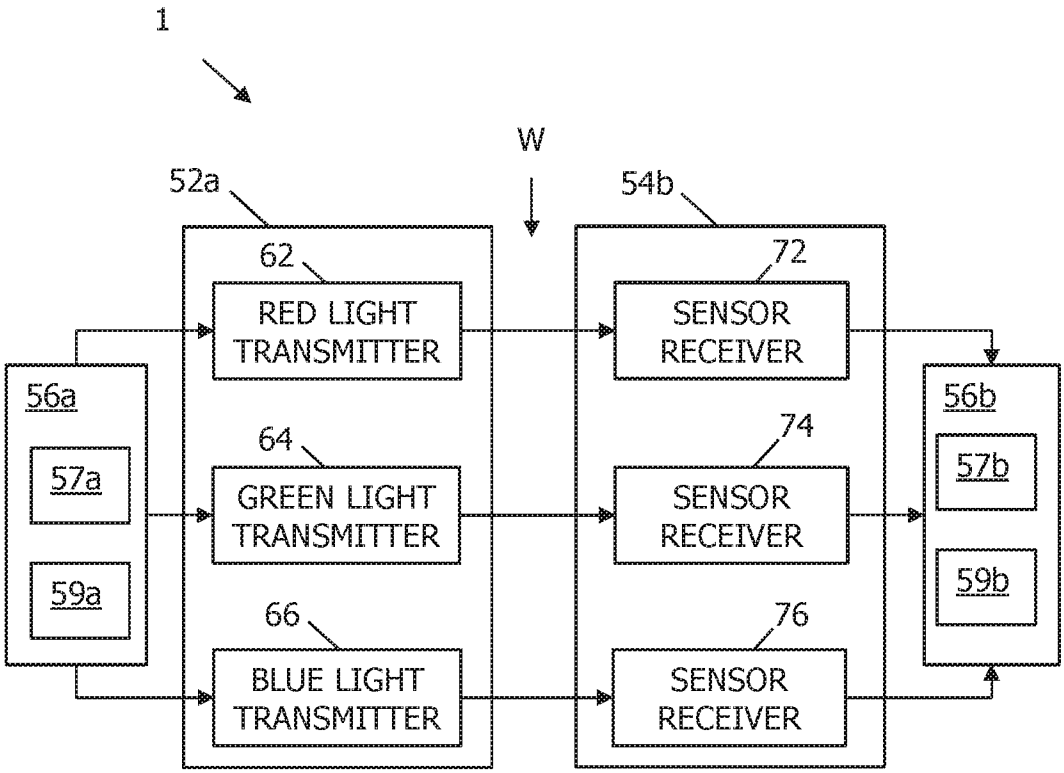
1
W
52a
54b
62
RED LIGHT TRANSMITTER
72
SENSOR RECEIVER
56a
57a
59a
64
GREEN LIGHT TRANSMITTER
74
SENSOR RECEIVER
56b
57b
59b
66
BLUE LIGHT TRANSMITTER
76
SENSOR RECEIVER

Figure 7

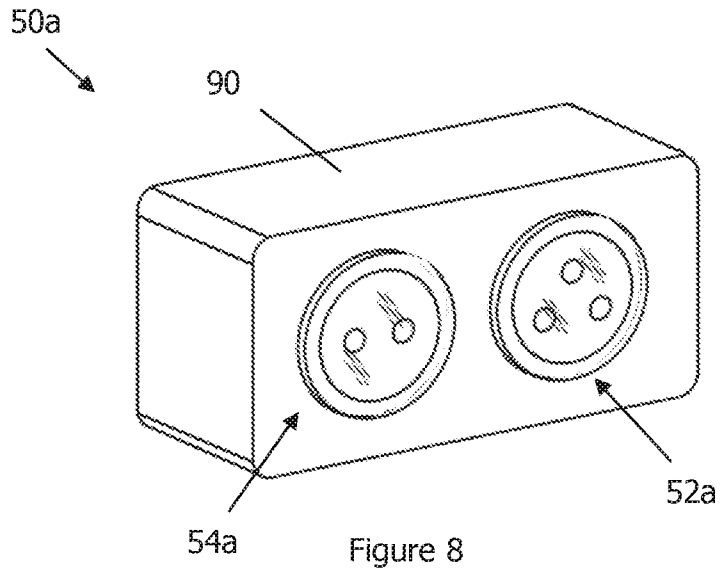

Figure 8

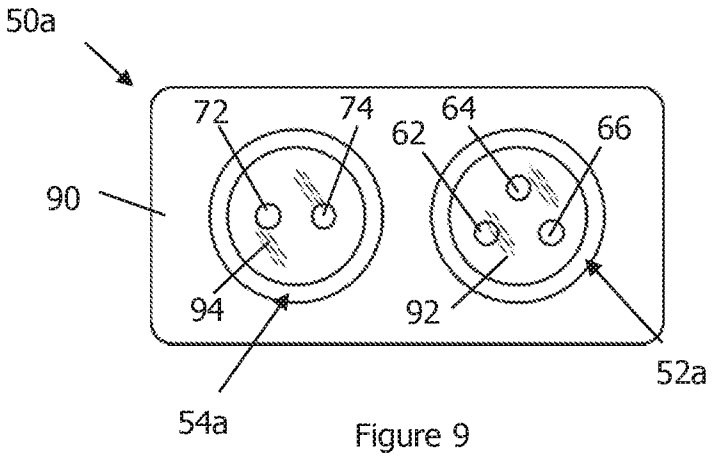

Figure 9

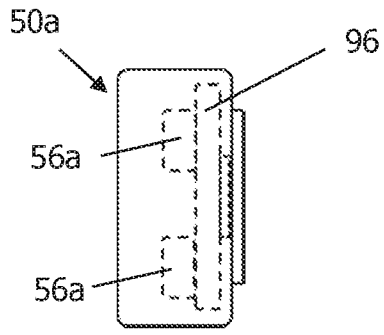

Figure 10

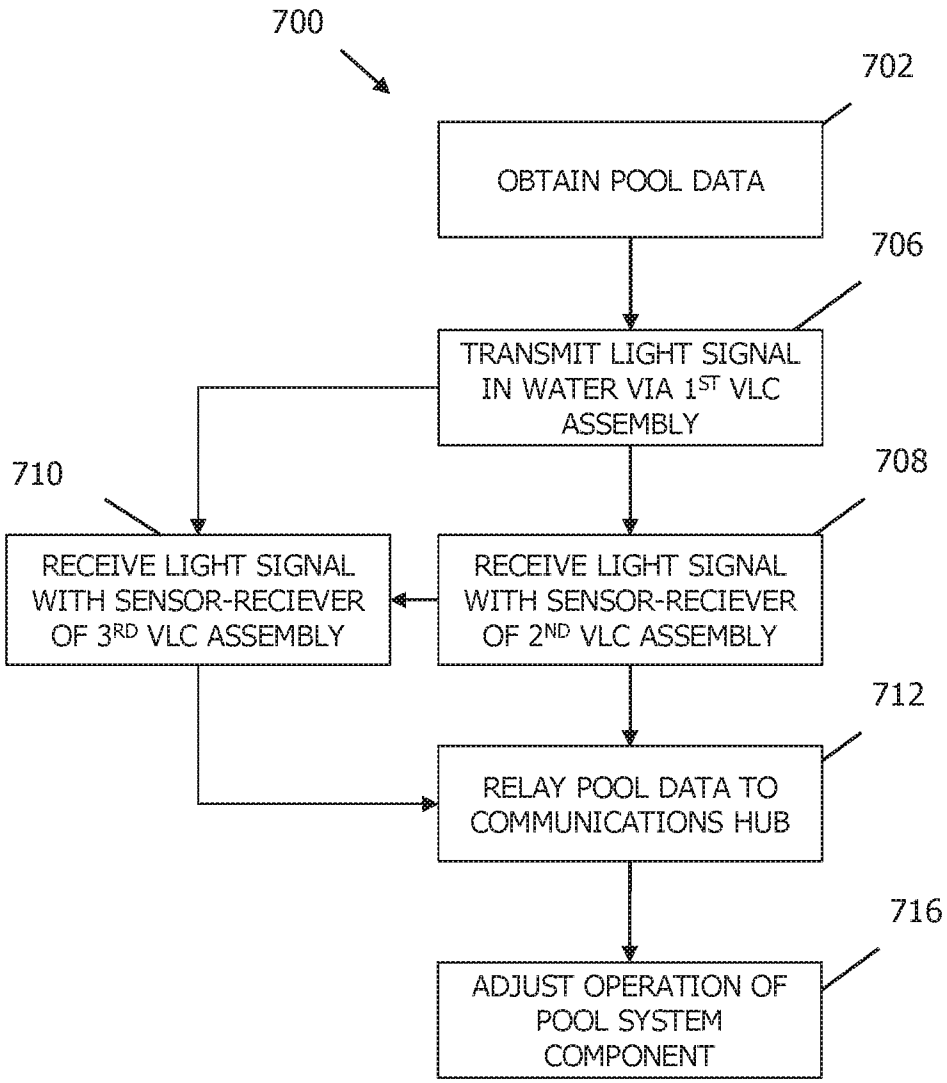
700
702
OBTAIN POOL DATA
706
TRANSMIT LIGHT SIGNAL IN WATER VIA 1ST VLC ASSEMBLY
710
708
RECEIVE LIGHT SIGNAL WITH SENSOR-RECIEVER OF 3RD VLC ASSEMBLY
RECEIVE LIGHT SIGNAL WITH SENSOR-RECIEVER OF 2ND VLC ASSEMBLY
712
RELAY POOL DATA TO COMMUNICATIONS HUB
716
ADJUST OPERATION OF POOL SYSTEM COMPONENT

Figure 11

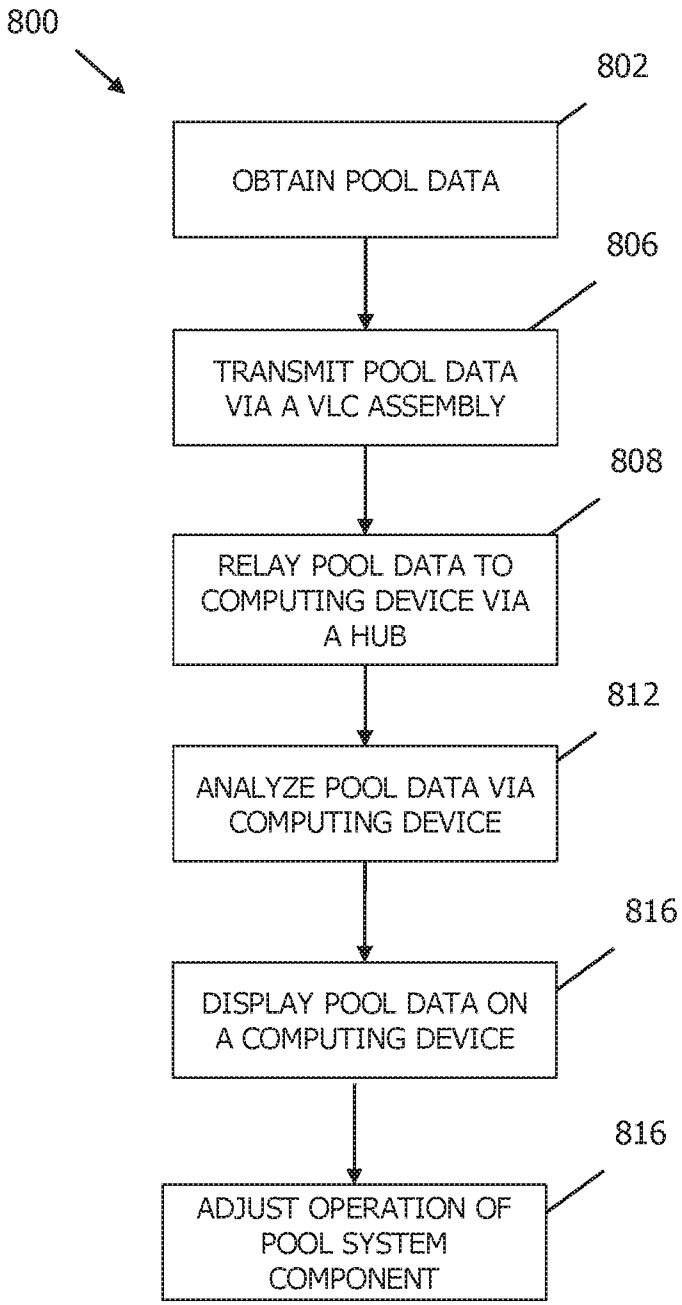
800
802
OBTAIN POOL DATA
806
TRANSMIT POOL DATA VIA A VLC ASSEMBLY
808
RELAY POOL DATA TO COMPUTING DEVICE VIA A HUB
812
ANALYZE POOL DATA VIA COMPUTING DEVICE
816
DISPLAY POOL DATA ON A COMPUTING DEVICE
816
ADJUST OPERATION OF POOL SYSTEM COMPONENT

Figure 12

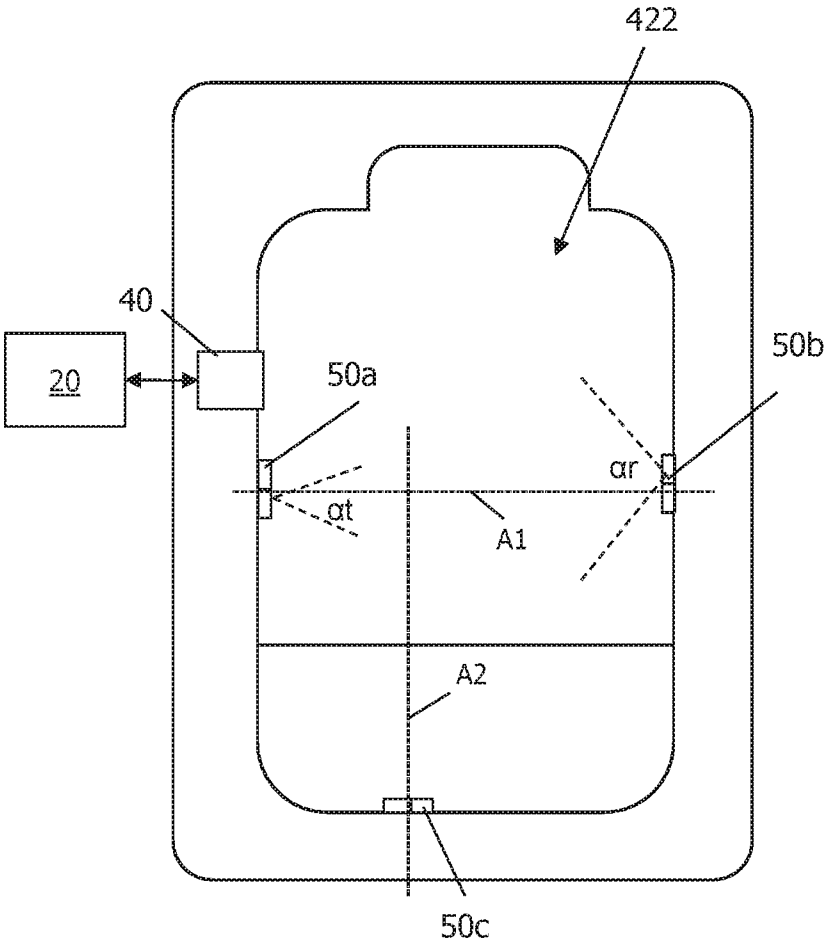

Figure 13

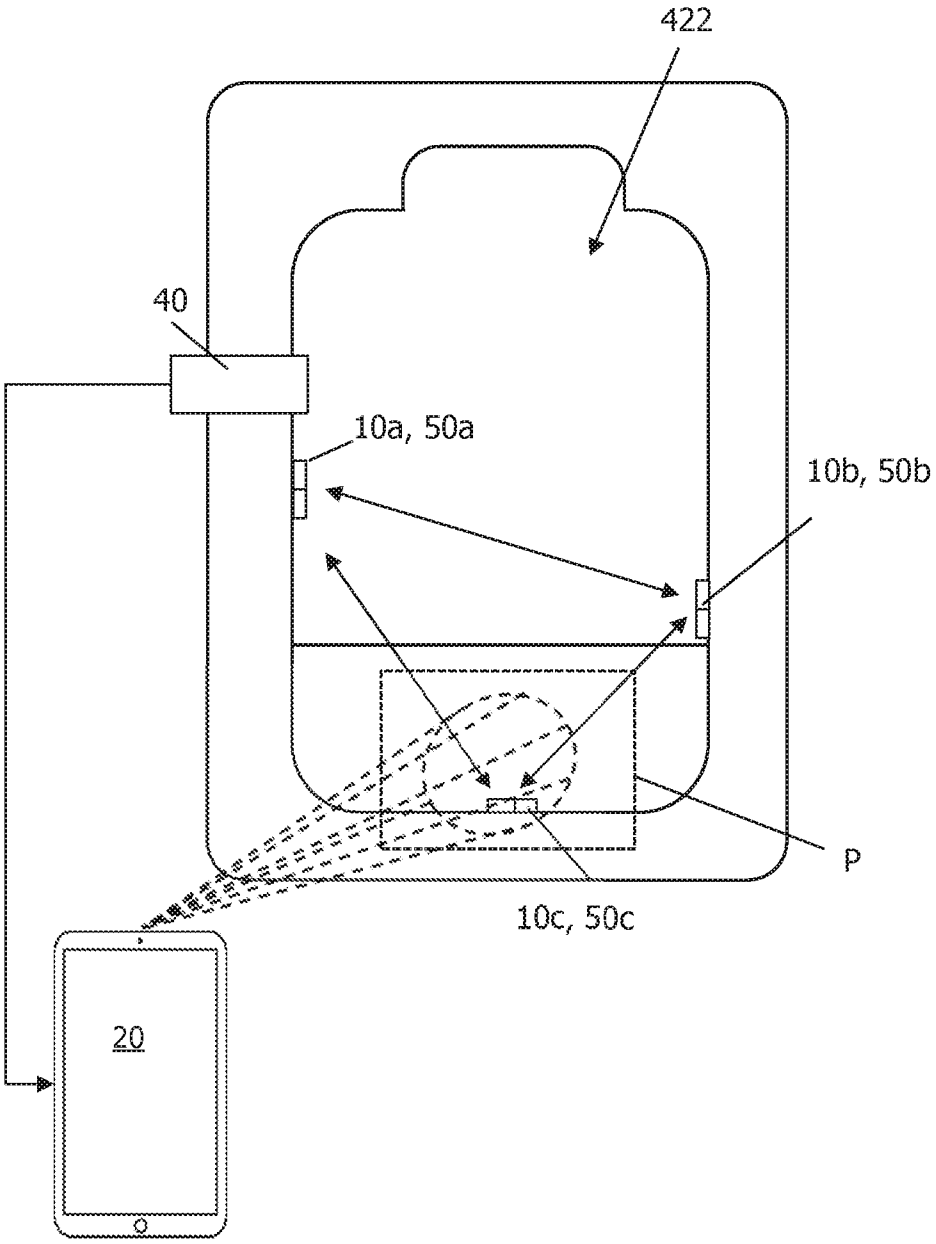

Figure 14

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/062602

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B10/116 E04H4/14 H04B13/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B E04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014/127742 A1 (FIELD CHRISTOPHER DAVID [AU]) 8 May 2014 (2014-05-08) abstract paragraphs [0004], [0005] paragraphs [0018] - [0032] paragraphs [0037] - [0042] paragraph [0056] figures 1A-1C, 2-4	1-65, 70-73, 78-84
Y	US 7 688 680 B1 (GUNASEKARA DON [US] ET AL) 30 March 2010 (2010-03-30) the whole document	1-65, 70-73, 78-84

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 April 2017	24/04/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Rolan Cisneros, E

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005/044617 A1 (MUELLER GEORGE G [US] ET AL) 3 March 2005 (2005-03-03) abstract paragraph [0076] paragraph [0093] paragraph [0104] paragraphs [0114] - [0120] paragraphs [0142] - [0148] figures 1, 2, 4, 8, 9	1-65, 70-73, 78-84
A	US 2011/241887 A1 (MCKINNEY GEORGE ANTHONY [US]) 6 October 2011 (2011-10-06) the whole document	1-65, 70-73, 78-84
A	WO 2009/149428 A1 (HAWKEYE SYSTEMS INC [US]) 10 December 2009 (2009-12-10) abstract page 7, line 5 - page 11, line 4 figures 1, 2	66-69, 74-77
A	US 2008/048870 A1 (LAITTA RICH [US] ET AL) 28 February 2008 (2008-02-28) the whole document	66-69, 74-77
A	KAWABATA KUNIAKI ET AL: "On-line image gathering by stationary and movable sensor node for underwater visual surveys", 2013 IEEE INTERNATIONAL CONFERENCE OF IEEE REGION 10 (TENCON 2013), IEEE, 22 October 2013 (2013-10-22), pages 1-4, XP032553855, ISSN: 2159-3442, DOI: 10.1109/TENCON.2013.6718521 ISBN: 978-1-4799-2825-5 [retrieved on 2014-01-21] the whole document	66-69, 74-77

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/062602

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-65, 70-73, 78-84

   Visible light communication system for a pool system comprising one or more light transmitters and light sensors related to some pool system components

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2. claims: 66-69, 74-77

   System and method for monitoring a pool system, capturing and displaying an image of a portion of a pool and sending instructions to receivers within that portion so that they transmit information about their status

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/062602

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014127742 A1	08-05-2014	US 2014127742 A1	08-05-2014
		WO 2014074087 A2	15-05-2014
US 7688680 B1	30-03-2010	NONE	
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US 2011241887 A1	06-10-2011	NONE	
WO 2009149428 A1	10-12-2009	US 2009303055 A1	10-12-2009
		US 2012269399 A1	25-10-2012
		WO 2009149428 A1	10-12-2009
US 2008048870 A1	28-02-2008	NONE	