

(19) World Intellectual Property  
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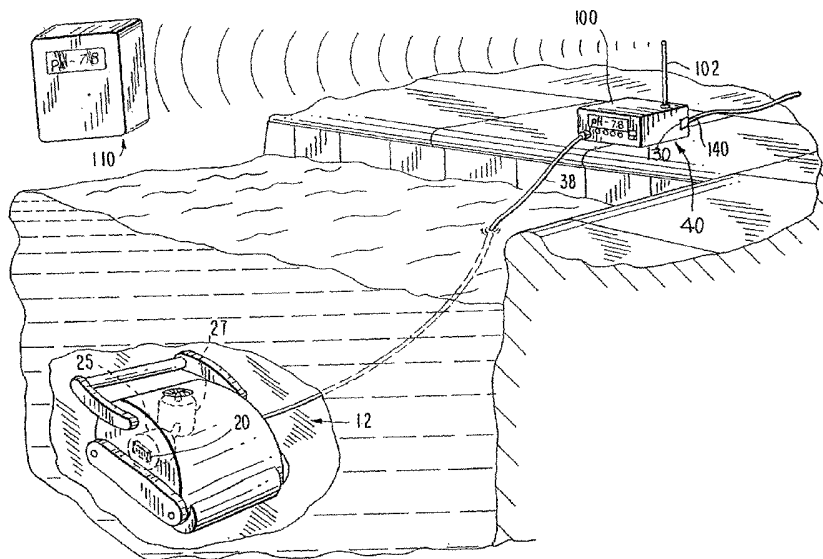
(43) International Publication Date  
4 March 2004 (04.03.2004)

PCT

(10) International Publication Number  
**WO 2004/019295 A1**

- (51) International Patent Classification<sup>7</sup>: **G08B 1/08**, 5/00, H04Q 1/30, E04H 4/16, B08B 7/04, G01N 27/416, E04H 3/16
- (21) International Application Number: PCT/US2003/026352
- (22) International Filing Date: 22 August 2003 (22.08.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data: 60/405,507 23 August 2002 (23.08.2002) US
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- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**  
— with international search report
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: POOL CLEANER WITH ON-BOARD WATER ANALYSIS, DATA RECORDING AND TRANSMISSION DEVICE



(57) Abstract: A self-propelled robotic pool cleaner (10) carries one or a plurality of sensors (20) for sensing and analyzing various water conditions in a pool or tank and periodically communicates the resulting information on the current value of each condition determined by a given sensor to a remote display device (44) for display and, optionally, to activate an audible (52) and/or visible (54) alarm to alert the person responsible for maintenance that one or more water conditions are outside of a pre-determined acceptable range. The display device (44) can be operated interactively to permit the user to enter information that establishes the acceptable range of water condition values.

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**POOL CLEANER WITH ON-BOARD WATER ANALYSIS,  
DATA RECORDING AND TRANSMISSION DEVICE**

**Field of the Invention**

This invention relates to sensors and data recording and display devices used to analyze various characteristics of swimming pool water for the purpose of determining the need to add additional chemicals to change or to adjust, for example, the chlorine content and pH.

**Background of the Invention**

Various automated sensing and analysis devices have been developed to measure, record and display the level of free chlorine, oxidation reduction potential ("redox"), the pH value, hardness, total dissolved solids ("TDS") temperature and other characteristics and conditions of swimming pool water in order to simplify and facilitate the maintenance of the conditions within a desired or optimum range. These devices include a sensor capable of periodically sampling and measuring the pH and the free chlorine ion level of water. The results of the analysis are converted to digital form by circuitry known to the art and stored in the memory of a microprocessor. The stored data can be accessed for display to determine whether any maintenance action is required to restore the conditions of the water to the desired pH and chlorine content range. These devices can also be activated to obtain a display of conditions on demand. The display is via an LCD screen of the type commonly found on pagers and cellular telephones.

The water is typically sampled by means installed in the piping associated with the water filter treatment apparatus. The purchase price, installation expense and maintenance costs associated with this prior art system can be substantial. Means for accessing a display or read-out must also be provided. Thus, the prior art requires  
5 that a complete, separate system and apparatus be installed and periodically checked at a location that may not be particularly convenient, such as a filter room or filter house located under the pool or in an even more remote location.

In addition to being inconvenient, the systems of the prior art require the owner to remain vigilant to weather conditions, such as outdoor temperatures, extent  
10 of sunshine and the like, which can have a marked effect on the frequency with which conditions of the pool water can change. Quite simply, the owner must remember to check the system in order to maintain the water in a safe and healthy condition.

For most residential pools, the home owner and/or his family members, a gardener or other employee with other principal duties will be responsible for pool  
15 maintenance. Since water conditions can fall outside of the desired or safe range without a visible manifestation, an improved system is required to alert the person responsible for monitoring pool maintenance that conditions should be checked and some remedial action be taken.

It is therefore an object of the present invention to provide sensing, analysis,  
20 recording, data processing and display apparatus that is integrated directly into a robotic pool cleaner assembly and one or more ancillary components, and which is

readily accessible either on a component of the assembly or on the remote stationary or hand-held device dedicated to this purpose.

A further object of the invention is to provide an improved apparatus and method for monitoring and analyzing the condition of the water in a swimming pool  
5 or other tank or vessel by directly reading the conditions in the volume of liquid contained in the pool rather than liquid passing through a conduit or pipe and for providing a display of the relevant data reflecting such conditions at predetermined periodic intervals and/or on demand.

It is yet a further object of the invention to provide means and a method for  
10 displaying such data that will not require modifications of the filter or piping system used to treat and carry the water, to thereby minimize the expenses associated with obtaining and displaying such information.

It is yet another object of the invention to provide an automatic apparatus and method that will provide a signal alerting a change in conditions requiring  
15 maintenance or remedial action and to also provide customized instructions and data as to the maintenance or remedial action required, including, for example, the amount and type of one or more chemicals that must be added to restore the condition of the water to a predetermined desired level or range based upon the specific type of chemicals that have been used historically in the maintenance of the pool being  
20 monitored.

### Summary of the Invention

The above objects and other advantages are achieved by the invention in which a robotic pool cleaner used to clean the bottom wall of a pool or tank is provided with on-board sensor and analysis means for measuring one or more characteristics or  
5 conditions of the water in the pool, a programmed microprocessor for receiving data from the sensor and analysis means, data storage means associated with the microprocessor, data transmitting means and associated display means for displaying data derived from the sensor means.

As used herein, the term "sensor" means any one or more of commercially  
10 available devices that have the ability to sample water in which the device is immersed, analyze the content of the water for one or more parameters including, for example the level of free chlorine, oxidation reduction potential ("redox"), the pH value, hardness, total dissolved solids ("TDS") and temperature, and to store or transmit for storage the results of the analysis in digital form.

15 Sensors suitable for use in the practice of the invention are available from commercial sources including the following : Omega USA of Stamford, CT., [www.omega.com](http://www.omega.com); Honeywell Sensing and Control of Freeport, IL., <http://content.honeywell.com/sensing/products/analytical>; Signet Scientific Company, <http://www.gfsignet.com>; Hanna Instruments S.P.A. of Padova, Italy,  
20 <http://www.hannainst.com>; and ZD Instrument Co. of Jiangsu Province, China; <http://www.zdinstrument.com>.

When a remote power supply is used, the data is transmitted from the operating submerged pool cleaner via a separate data cable that is attached to the power cable or contained within the same insulating cover as the power conductors. The data transmission line(s) can be a shielded coaxial cable. The data line is then  
5 attached to the data display device. The connection can be permanent or via a jack when a separate data line is employed.

In one preferred embodiment, where the robotic pool cleaner receives its power from a remote power supply located outside of the pool, the data display means is associated with the power supply, either in a separate housing mounted on the  
10 exterior of the power supply or by incorporating the display means into the power supply housing. In a particularly preferred embodiment, the display means is interactive and includes a switch for activating the display screen and, in an especially preferred embodiment, a keypad or function keys that is operable by the user to advance the various characteristics and conditions that have been stored in the  
15 microprocessor's memory device and to selectively view the instructions for remedial action, such as chemical type and quantity that is to be added to restore the desired condition of the pool water.

In a second preferred embodiment, the pool cleaner is powered by an integral rechargeable battery and is provided with an antenna, the transmitting end of which  
20 floats on the surface of the pool water to transmit a signal to either or both of a stationary or a hand-held device. The transmission of data can be programmed for a periodic transmission or in response to signal from the receiver/display device that is

passed through the floating antenna to the microprocessor which is activated to transmit stored data from the last test or series of tests. In a particularly preferred embodiment, the hand-held display device can be configured similarly to a cell phone with a case, antenna, display screen, keypad and battery power supply. Alternatively, 5 the hand-held device can be configured similar to a television remote control device.

The sensor means can be positioned on the interior of the housing of the pool cleaner in an active flow path of water being drawn into the pool cleaner filter assembly. This location provides an accurate sampling of the actual conditions in the pool and also protects the sensors from damage.

10 Alternatively, the sensors can be mounted on the exterior of the housing in a protective casing through which casing pool water to be sampled will flow. Sensor conductor leads pass through openings in the cleaner housing to the microprocessor memory unit.

The power requirements for the sensor, microprocessor and transmitter are 15 obtained from the power supplied to the pool cleaner to operate the pump or pumps and any drive motor or motors. As noted above, this can be a remote power source located outside of the pool or a rechargeable battery that is also positioned inside the pool cleaner housing.

For a battery-powered pool cleaner, a separate antenna wire must be provided, 20 with the free end floating at the surface of the pool water. The antenna is preferably attached via a plug and jack assembly passing through the pool cleaner housing that is attached to the microprocessor and transmitter circuit. In this way, the antenna can

be removed and coiled for storage when the cleaner is removed from the pool for maintenance or storage. Alternatively, the antenna can be attached to a manually operated reel or drawn from an automatic coiling device located on the exterior or interior of the pool cleaner housing.

5           As previously noted, the on-board sensor means can include means for analyzing any one or more of the water characteristics and conditions that are presently available or that may be developed in the future. A separate power source can be provided to the sensor unit(s) to permit their operation even when the pool cleaner is not operating to clean the pool. The separate power source can be a circuit  
10           supplied by the remote power supply or a separate rechargeable or dry cell battery. In this embodiment, the pool cleaner is left in the pool and will display or even signal a change in conditions requiring remedial action to restore the pool water.

          In the case of either the remote power supply or the integral battery power supply, the apparatus can include a remote hand-held display device having the  
15           characteristics of a pager, or a more sophisticated device that has additional interactive functional capabilities than the pager that can be carried by the user to interrogate the stored data.

          The programmed microprocessor can include the generation of an audible and/or visible warning signal to indicate that one or more of the measured conditions  
20           is outside of a predetermined acceptable range. For example, in heated swimming pools, the program for a temperature sensor can include an audible alarm to indicate when the water temperature has dropped below or exceeded a predetermined value.

Such a condition might arise in the event of a failure of the pool's heating element and/or its associated temperature sensor and thermostatic control device. A rise in water temperature will also cause more chlorine to be released into the atmosphere and will accelerate the replacement requirement for this chemical. Prompt remedial  
5 action can save time and money in restoring the desired balance.

The most common maintenance requirement for swimming pools is the addition of a source of chlorine ions in order to inhibit the growth of bacteria, algae and the like. The effect of direct sunlight and an increase in temperature is well known to reduce the level of chlorine ion. Thus, in a preferred embodiment of the  
10 invention, a chlorine sensor is included and the microprocessor is programmed to provide a signal to indicate when the chlorine level drops below the desired predetermined level.

In an especially preferred embodiment, the microprocessor and memory device is programmed to permit the owner to identify the particular type and form of  
15 chlorine-containing chemical that has historically been used in the treatment of the pool. For example, HTH is available in the form of a liquid additive, crystals and powder. A microprocessor is programmed to display a recommended amount of the particular type and form of chlorine ion chemical that must be added based upon the entry of data that includes the volume of water in the pool that must be treated. The  
20 program can also include other parameters, such as water temperature and sun load in identifying the volume and/or weight of chemical product to be added.

In one particularly preferred embodiment, the microprocessor is programmed with information about all of the known chemical products commonly used in a particular geographical area where the pool cleaner is to be sold. The programmed information can include trademarks and brand names. Algorithms are provided to  
5 account for water temperature, sun loads, water hardness ranges, pH ranges and such other parameters are customarily measured.

The user is provided with one or more menus from which are selected the particular brand and/or type of chemical used to maintain the pool in which the pool cleaner of the invention is to be used. The volume of the water in the pool is also  
10 entered. Thereafter, during use, the display will include a screen with information as to how much of the previously specific chemical is to be added to restore water conditions within the desired or prescribed range.

As will be apparent to one of ordinary skill in the art, that data from the on-board sensors can also be transmitted to a stationary data display device, such as a  
15 personal computer, portable notebook or laptop computer for access by the user. For convenience, all such computers will be referred to as "stationary devices" to distinguish them from the hand-held devices described above. The stationary display device can be located in the user's home. The pool monitoring system can also be incorporated into an advanced household monitoring system of the type that are  
20 known to the prior art.

Any of the various types of transmitting methods and apparatus known to the art or developed in the future can be adopted. In the case of a remote power supply,

the data display device can be hard-wired to one of more secondary display devices in the user's home. In the case of a battery-powered pool cleaner, one or more stationary receiving antennas can be positioned in the vicinity of the pool to pick-up the data signals from the microprocessor. If necessary or desired, the receiving  
5 antennas can be provided with booster to enhance the signal for retransmission.

The data transmission and receiving system of the invention further comprehends the use of the Internet for providing access to the data from other remote locations, either accessible to the owner or to a commercial pool servicing organization. This type of system can also be used by institutions, such as  
10 universities, municipal parks departments and the like, to monitor the conditions of numerous pools under their jurisdiction for the purpose of dispatching an employee to correct conditions that are not within acceptable ranges. Use of the invention in such circumstances would permit maintenance personnel to take action promptly on an as-needed basis to enhance efficiency, reduce costs and maximize operations within  
15 predetermined safety limits for the benefit of swimmers and others using the pools.

#### **Brief Description of the Drawings**

The invention will be described in more detail below and with reference to the attached drawings in which:

20 FIG. 1 is a schematic illustration of one preferred embodiment of a pool cleaner of the invention provided with an external sensor array in operation with a

remote power supply equipped with a data display screen and interactive display switches;

FIG. 2 is an enlarged front, top, right side perspective view of the power supply of FIG. 1;

5 FIG. 3 is a schematic illustration of the invention similar to FIG. 1 showing the sensor array positioned on the interior of the pool cleaner housing and its relation to a remote hard-wired data display device and pager and to an alternative hand-held device that communicates interactively with the hard-wired device;

FIG. 4 is a schematic illustration of the invention in which the power is  
10 supplied by a battery that is integral with the pool cleaner; and

FIG. 5 is a schematic block diagram of an interactive communications system in accordance with another preferred embodiment which integrates a battery-powered pool cleaner with a plurality of local and remote interactive data display devices and antennas, and an Internet link.

15

### **Detailed Description of the Preferred Embodiments**

In one preferred embodiment of the invention illustrated in Fig. 1, a pool cleaner generally referred to as 10, is provided with an external sensor array 20 comprising one or more sensors (or sensors/analyzers) 23 contained in a protective  
20 housing 21 provided with one or more water sampling inlets 22. Each sensor 23 is adapted to sense a respective condition of the water in the pool and is therefore physically disposed in or on the pool cleaner 10 so as to be in sensing relation to the

water. In this embodiment, an external power supply 40 is connected to the pool cleaner 10 by power cable 50.

A preferred arrangement of the display and controls as integrated into the casing of the power supply housing 42 is illustrated in Fig. 2. Liquid crystal display 5 44 is prominently positioned for easy viewing on a front or top side surface of housing 42. A multi-conductor power supply cable outlet 50 is mounted through the housing 42 and includes terminals 51 for receiving information (data) transmitted from the one or more sensors 23 in the pool cleaner 10. The power supply 40 is also provided with an on/off power switch 46 and one or more, but preferably a plurality 10 of, function and characteristic display switches in the form of pushbuttons 48. These function actuators 48 interact with the microprocessor (not illustrated) that is either located in the power supply housing 42 or more preferably, on-board the pool cleaner.

In one preferred method of practicing the invention, the one or more sensors 15 23 are periodically activated and the data generated processed to determine whether it is within the predetermined acceptable range. In the event that the data is outside the desired range, an audible alarm can be generated from signal unit 52 and/or a visible signal device such as flashing light 54 is activated. Either or both of these signal devices can be omitted or deactivated and the user can interrogate the device to obtain 20 a on-demand display of the data for any one or more of the characteristics stored in the microprocessor's memory device. In a particularly preferred embodiment, the

microprocessor is programmed to display the acceptable value or range along with the most recent actual analysis result.

The display also preferably prompts the user with information about the proactive or remedial action to be taken, such as "add chlorine." In this embodiment  
5 the microprocessor memory device is programmed with information concerning the specific type (i.e., liquid, crystal, powder) and strength or concentration and brand name of the chemicals historically used to treat the pool to maintain its balance. In this embodiment, the user can be prompted to display the required type and amount of chemical additive to be used, taking into account other variables such as the actual  
10 volume of the water contained in the pool, water temperature and the like. The programming of microprocessors with this information for use in an interactive manner is known to the art and/or can be extended in accordance with the teachings of the invention by one of ordinary skill.

In the alternative embodiment illustrated in Figure 3, showing the interior of a  
15 pool cleaner 30 that has been turned upside down for clarity, the sensor array 20 can be incorporated into the casing 25 positioned on the interior of the housing in the active flow path of the water that has been drawn through the filter bag 27. This particular configuration, with the sensors 23 located on the interior of the housing 12, is preferred in order to minimize the possibility of damage by mishandling the pool  
20 cleaner 30. This is also a preferred location for the sensor array 20 if the cleaner 30 is to be left in the pool when it is not performing its cleaning operations.

A further embodiment of the invention is illustrated in Fig. 4 where the pool cleaner power is supplied by an on-board rechargeable battery 31, which eliminates the need for an external power cable. In this embodiment, the data must be transmitted through an antenna 70, the transmitting end 72 of which floats on the surface of the pool water.

The antenna 70 can be terminated by a jack and mating plug assembly 74 to permit removal from the housing during storage. A signal transmitting cable 76 links the antenna 70 to the sensor array assembly.

In this embodiment, a remote display device, which can be a hand held display 120 (see Fig. 4), a PC or laptop computer 125 (see Fig. 5) with an appropriate receiving and transmitting antenna 205 of its own or a stationary receiver 100 configured similar to that of the power supply display module 40 described above, can be employed. The stationary receiving transmitter 100 may receive the signal from the floating antenna 70 and retransmit it via antenna 102 to the pager 110 or a more interactive hand-held remote control device 120 (see Fig. 5). Here a separate power cable 38 may be used.

The remote receiving antenna 205 can be installed on a mast 200 dedicated to that use, on a building 210 or home proximate the pool, or at any other convenient location that is within range of the floating antenna.

In the embodiment depicted in Fig. 5, the stationary receiving transmitter 100 receives the signal from the floating antenna 70 and retransmits it via antenna 102 to pager 110 or the more interactive hand-held remote control device 120.

The transmitter/receiver 100 can also be provided with a modem 130 allowing direct access and communication of data via telephone lines 140 or satellite through the Internet to either type of device 110 or 120.

Transmitter receiver 100 can also be integrated into commercially available  
5 electronic home monitoring and control systems. The receiver 100 can be hard-wired or connected via antenna 210 and a separate receiver transmitter unit. Such systems typically include signal-type alarms to alert the home owner to conditions requiring attention. The systems also permit the interactive scanning of data that is collected and stored in the system's memory. In a particularly preferred embodiment of the  
10 invention, the pool cleaner chemicals are stored in reservoirs connected to automated measuring and injection valves to permit maintenance of the system from the keypad of a PC or other interactive controller keypad forming part of the system.

While the disclosed method and apparatus have been particularly shown and described with respect to the preferred embodiments, it will be apparent to those  
15 skilled in the art from the description provided that various modifications in form and detail may be made therein without departing from the scope and spirit of the invention. Accordingly, modifications such as those suggested above, but not limited thereto are to be considered within the scope of the invention, which is to be determined by reference to the appended claims.

## I CLAIM:

1. A self-propelled robotic pool cleaner for cleaning at least a submerged lower wall of a pool or tank containing water, said pool cleaner comprising:
  - 5 a cleaner housing;
  - a sensor array including at least one sensor, said array being supported by said cleaner housing in a position at which each of said at least one sensor is in sensing relation to the water as said pool cleaner moves, each sensor of said array further sensing a specific condition of the water;
  - 10 a power source electronically connected to said sensor array to operate each of said at least one sensor; and
  - means for outputting information to a remote display on each condition sensed by said at least one sensor on said array .
  
2. The pool cleaner of claim 1, wherein said sensor array is positioned in the interior of said cleaner housing in an active flow path of water through said pool cleaner.
  
3. The pool cleaner of claim 1, further comprising a protective housing including at least one water inlet mounted on an exterior surface of said cleaner housing, said sensor array being mounted within said protective housing such that

water entering said protective housing through said at least one water inlet flows in contact with said at least one sensor in said sensing relation.

4. The pool cleaner of claim 1, wherein said means for outputting information includes a data cable extending from said cleaner housing for connection to the remote display.

5. The pool cleaner of claim 4, wherein said power source includes a power cable extending from said cleaner housing for connection to a remote source of electrical power, and said data cable comprises at least one conductor within said power cable.

6. The pool cleaner of claim 1, wherein said means for outputting information includes a wireless transmitter for transmitting the information as a wireless signal from said pool cleaner to the remote display.

7. The pool cleaner of claim 1, wherein said wireless transmitter includes an antenna having a free end adapted to float on an upper surface of the water in the pool.

8. The pool cleaner of claim 6, wherein said power supply includes a power cable extending from said cleaner housing for connection to a remote power source.

9. The pool cleaner of claim 1, wherein said power arrangement includes a battery within said cleaner housing for acting as a power source.

10. The pool cleaner of claim 1, further comprising a processor for processing data from said sensor array to generate the information to be output.

11. A self-propelled robotic pool cleaning system for cleaning at least a submerged lower wall of a pool or tank containing water, said pool cleaning system comprising:

a pool cleaner comprising:

5 a cleaner housing;

a sensor array including at least one sensor, each of said at least one sensor being supported by said cleaner housing in a position in sensing relation to the water as said pool cleaner moves, each sensor of said at least one sensor sensing a specific condition of the water;

10 a power source for supplying power to said sensor array to operate each said at least one sensor; and

information output means for transmitting information on a condition sensed by each of said at least one sensor; and

a remote display device in communication with said information output means.

12. The system of claim 11, wherein said sensor array is positioned in the interior of said cleaner housing in an active flow path of water.

13. The system of claim 11, said pool cleaner further comprising a protective housing including at least one water inlet mounted on an exterior surface of said cleaner housing, said sensor array being mounted in said protective housing such that water entering said protective housing through said at least one water inlet flows in sensing contact with said at least one sensor.

14. The system of claim 11, wherein said information output means includes a data cable operatively extending from said cleaner housing for connection to said remote display device.

15. The system of claim 14, wherein said power source includes a power cable extending from said cleaner housing for connection to a remote power source, and said data cable comprises at least one conductor in said power cable.

16. The system of claim 15, wherein the power source is positioned in a power supply housing and said remote display device is included in the power supply housing.

17. The system of claim 11, wherein said means for outputting information includes a wireless transmitter for communicating a signal from said pool cleaner to said remote display device.

18. The system of claim 17, wherein said wireless transmitter includes an antenna having a free end adapted to float on an upper surface of the water.

19. The system of claim 17, wherein said power source includes a rechargeable battery mounted in said cleaner housing.

20. The system of claim 11, wherein said power source includes a power cable extending from said cleaner housing for connection to a remote power source.

21. The system of claim 20, wherein the power source is positioned in a power supply housing and said remote display device is located at the power supply housing.

22. The system of claim 11, further comprising means for generating an audible and/or visible alarm signal in response to said sensor array detecting a predetermined unacceptable value for a water condition.

23. The system of claim 22, wherein said remote display device includes a display housing and said alarm generating means is on said display housing.

24. The system of claim 23, wherein said display device displays an acceptable range for the value of a water condition and a most recent value of the same water condition as determined by a sensor on the pool cleaner.

25. The system of claim 22, wherein said pool cleaner further comprises a processor for processing data from said sensor array to generate the information to be output.

26. The system of claim 11, wherein a predetermined one of said pool cleaner and said remote display device includes a processor for analyzing the information output from said sensor array, said display device providing an alarm signal in response to said processor determining that at least one condition detected by said sensor array requires remedial action.

26. The system of claim 25, wherein said processor includes an algorithm employing a predetermined range of values corresponding to each of one or more water conditions to determine whether a corresponding sensed water condition requires remedial action.

27. The system of claim 26, wherein said display device is interactive to permit input of additional information to said processor, and wherein the algorithm further employs the additional information input to said processor to determine whether at least one condition requires remedial action.

28. The system of claim 11, wherein said display device is hand-held.

29. The system of claim 11, wherein said display device is stationary.

30. The system of claim 11, wherein said display device communicates a recommendation for remediating the at least one condition detected by said sensor array that requires remedial action.

31. A method of operating a pool cleaning system for cleaning at least a submerged lower wall of a pool or tank containing water, wherein the pool cleaning system comprises:

a self-propelled robotic pool cleaner, comprising a cleaner housing, a sensor array including at least one sensor, the array being supported by the cleaner housing in sensing relation to the water and a power arrangement for supplying power to the sensor array to operate said at least one sensor, and

a remote display device,

said method comprising the steps of:

sensing at least one condition of the water using a sensor of the array;

outputting information to the remote display as to each of said at least one conditions sensed by said array; and

displaying information relevant to the at least one condition of the water.

32. The method of claim 30, further comprising the step of generating an audible and/or visual alarm signal in response to said sensing step sensing a predetermined undesirable value for at least one of the water conditions.

33. The method of claim 30, wherein the display device includes a processor for analyzing the information from the pool cleaner, said method further comprising the step of providing an alarm signal in response to the processor determining that at least one condition sensed in said sensing step requires remedial action.

34. The method of claim 33, wherein said step of providing an alarm signal includes the step of communicating a recommended action for remediating the at least one condition that requires remedial action.

35. The method of claim 34, wherein said step of providing an alarm signal includes the step of applying an algorithm in the processor to employ the information to determine whether at least one condition requires remedial action.

36. The method of claim 35, wherein the display device is interactive and receives the input of additional information to the processor, and wherein said step of applying the algorithm further applies the additional information input to the processor to determine whether at least one condition requires remedial action.

FIG. 1

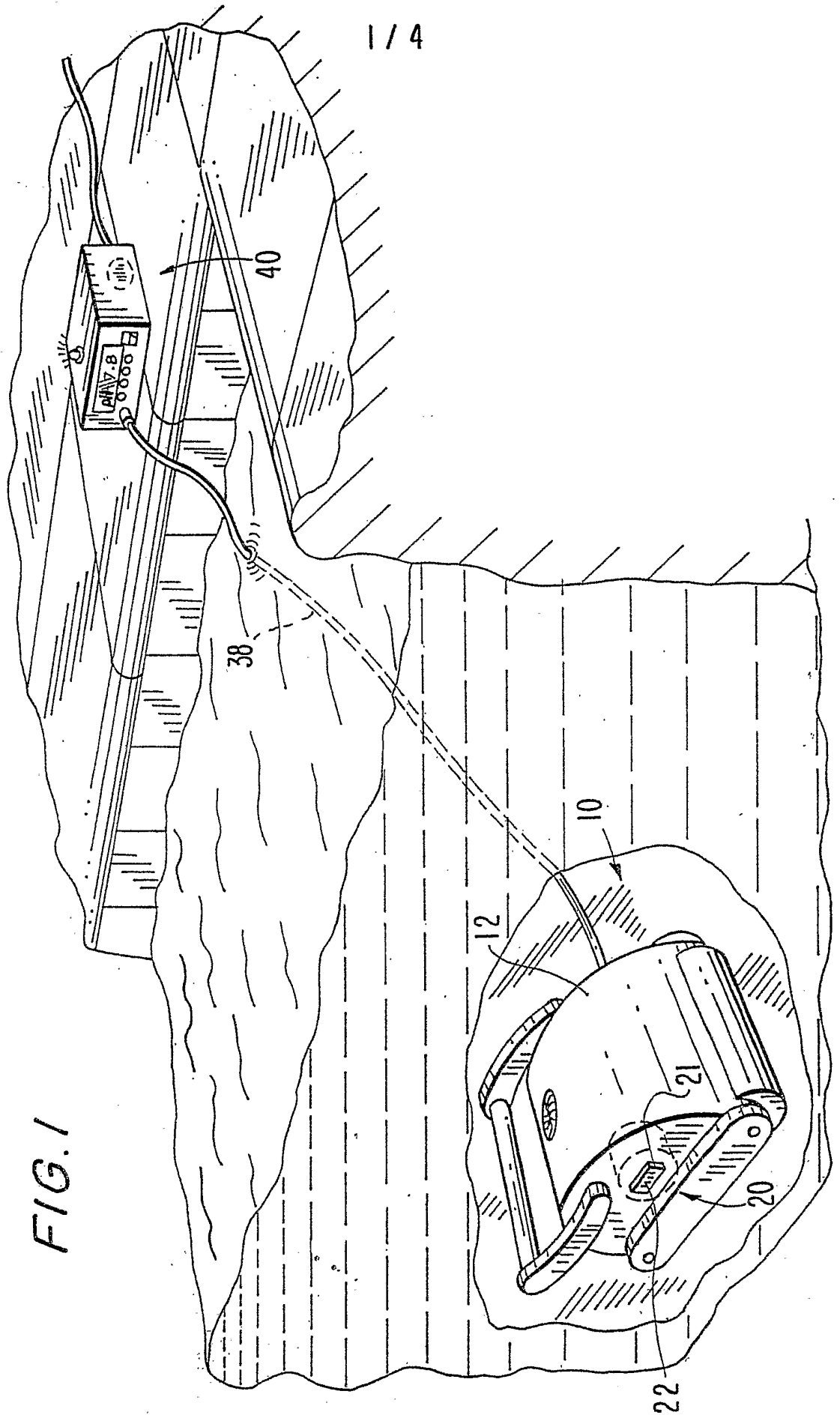


FIG. 2

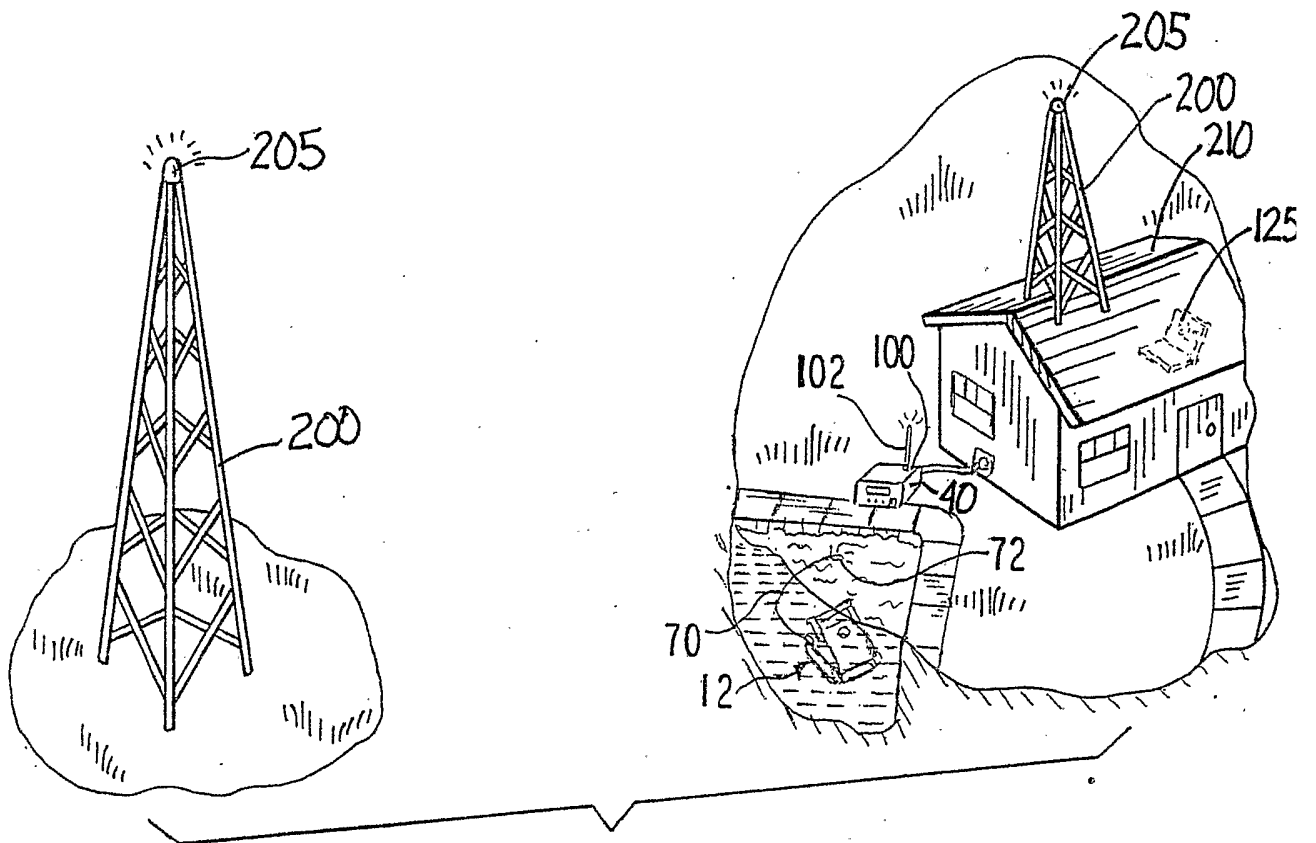
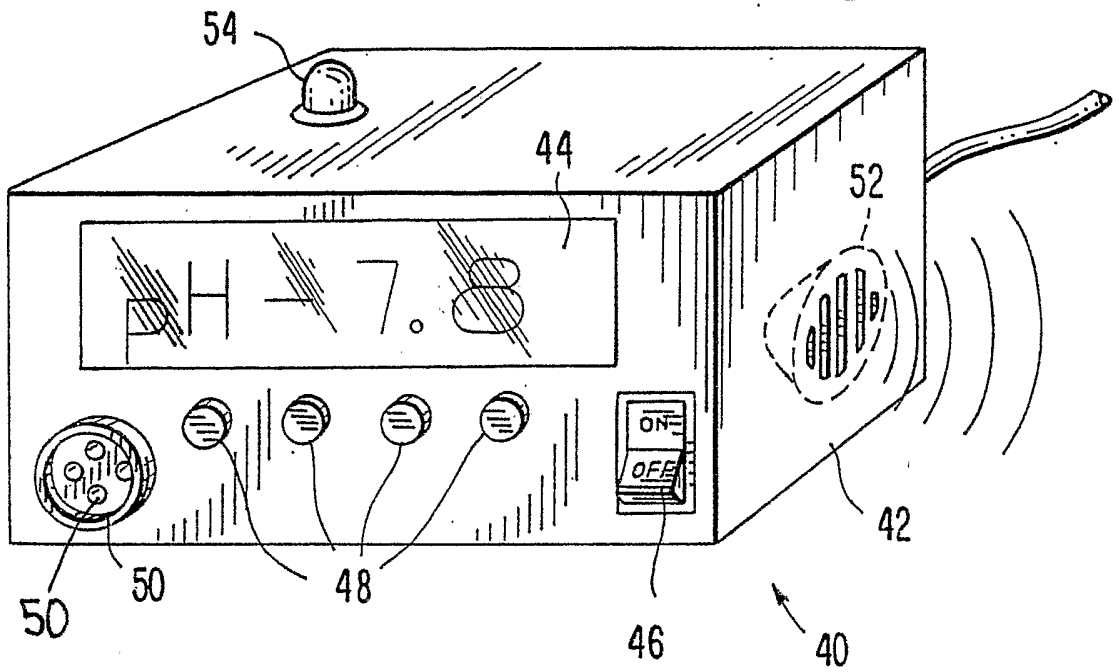


FIG. 5

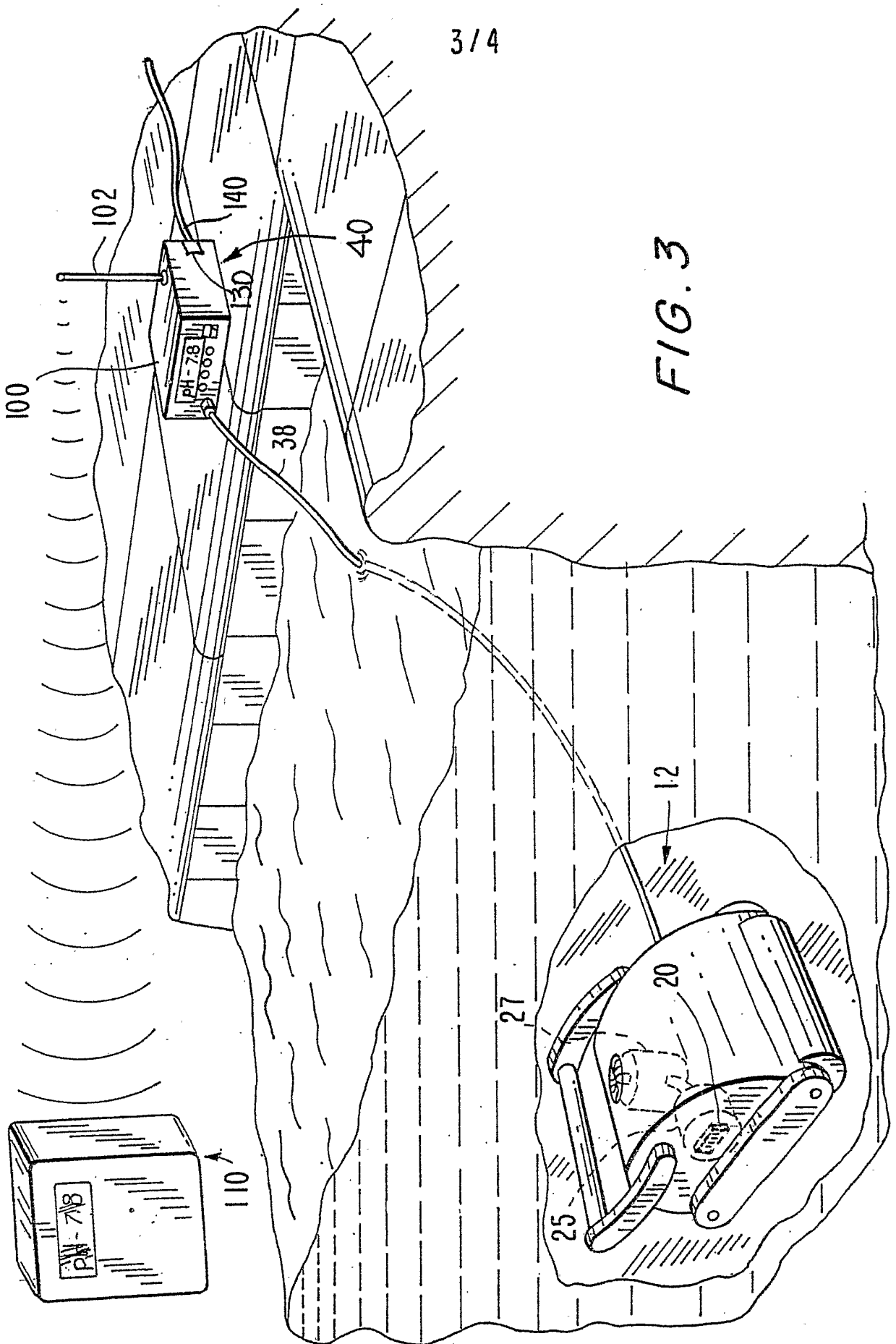


FIG. 3



**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US03/26352

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(7) : G08B 1/08, 5/00; H04Q 1/30; E04H 4/16; B08B 7/04; G01N 27/416; E04H 3/16  
 US CL : 340/539.1, 573.1, 691.1; 15/1.7; 134/18; 324/438; 210/169

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)  
 U.S. : 340/539.1, 573.1, 691.1; 15/1.7; 134/18; 324/438; 210/169

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)  
 Please See Continuation Sheet

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,222,449 B1 (TWINING) 24 April 2001, col. 4, lines 7-10; and col. 5, lines 19-32.	1-36
Y	US 5,218,304 A (KINLEN et al) 08 June 1993, col. 2, lines 50-55; col. 4, lines 16-31; and col. 6, lines 7-15.	1-36
Y	US 5,337,434 A (ERLICH) 16 August 1994, col. 2, lines 44-59; and col. 4, lines 48-55.	1-36

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

23 November 2003 (23.11.2003)

Date of mailing of the international search report

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**INTERNATIONAL SEARCH REPORT**

PCT/US03/26352

**Continuation of B. FIELDS SEARCHED Item 3:**

EAST Search term: robotic pool cleaner, sensor, water conditions, power source, remote display, transmitter, audible/ visual alarm.