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INTELISANO

(54) **GROUNDWATER SAMPLING DEVICE**

(75) Inventor: **Craig INTELISANO**, Bradenton, FL (US)

Correspondence Address:
Novak, Druce & Quigg LLP
1300 I Street, N.W., Suite 1000, West Tower
WASHINGTON, DC 20005 (US)

(73) Assignee: **Concurrent Technologies International, LLC**, Sarasota, FL (US)

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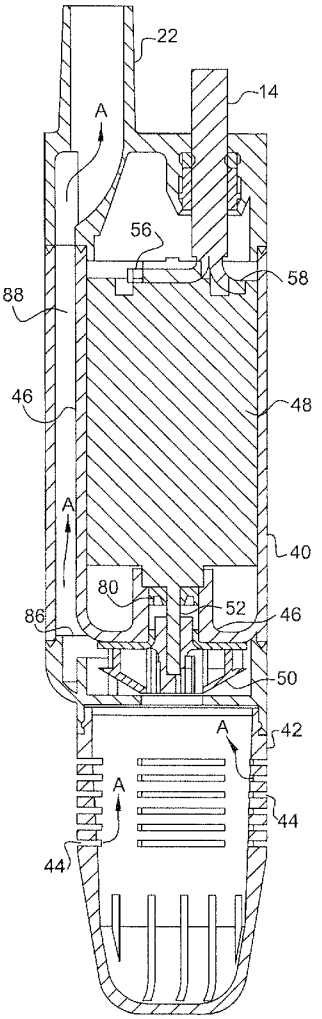
(57) **ABSTRACT**

A groundwater sampling and pumping device and system for withdrawing groundwater from a well of small size, not exceeding 1.5 inches I.D. The device includes a hollow outer housing having water inlet ports formed through a bottom thereof and a hollow inner housing sized to be positioned integrally within the outer housing and defining a water flow passage therebetween. An electric motor in the inner housing is connected to a water impeller operably positioned to draw groundwater into the water passage. The water passing upwardly through the water flow passage provides cooling for the motor. Preferably the housing is formed of a polymer material, and/or a metal, such as stainless steel.



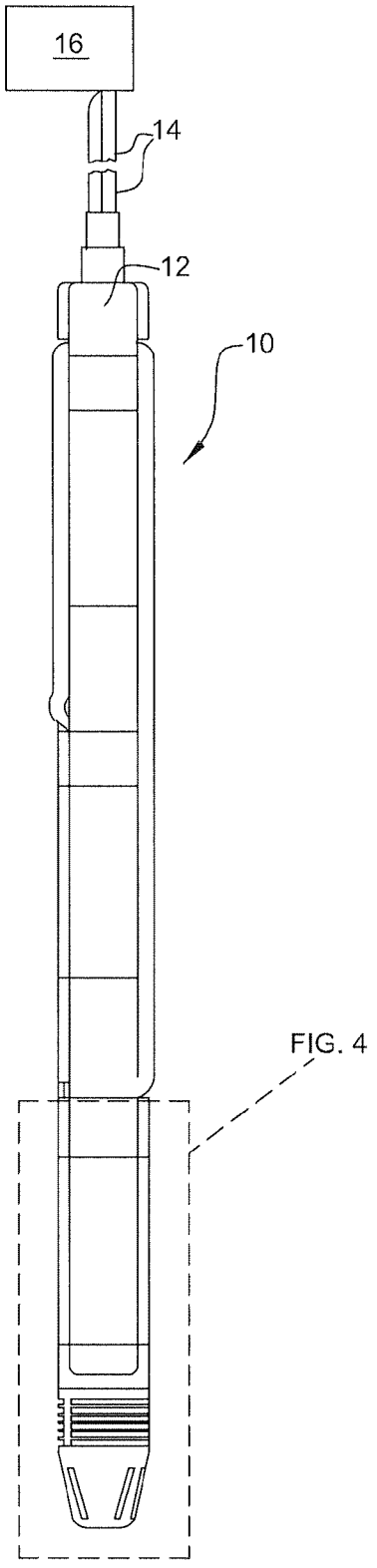


FIG. 1

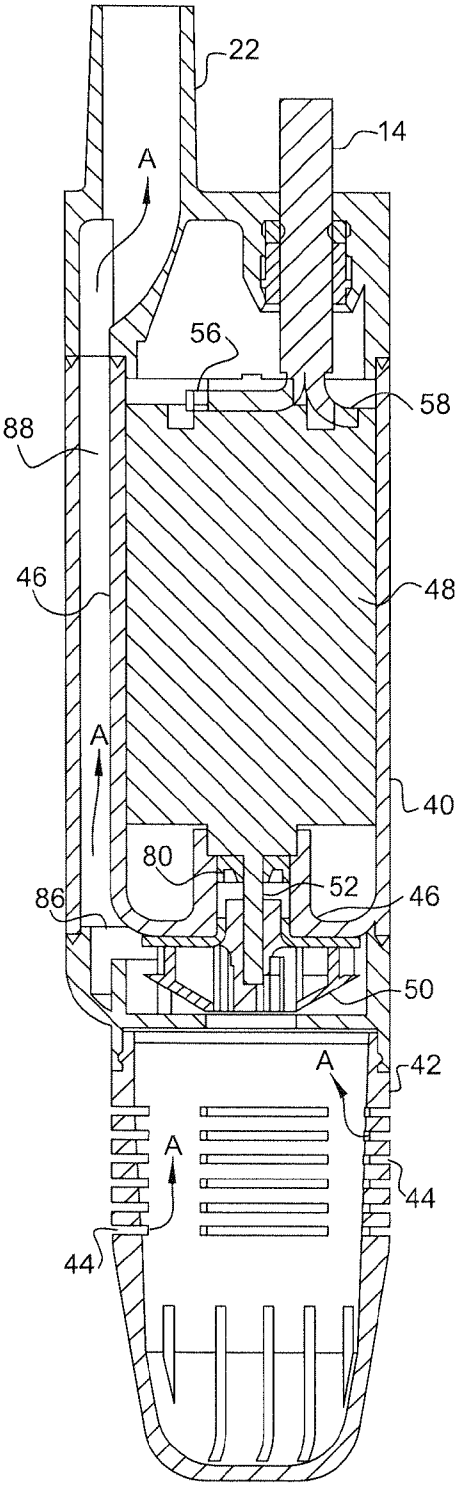


FIG. 4

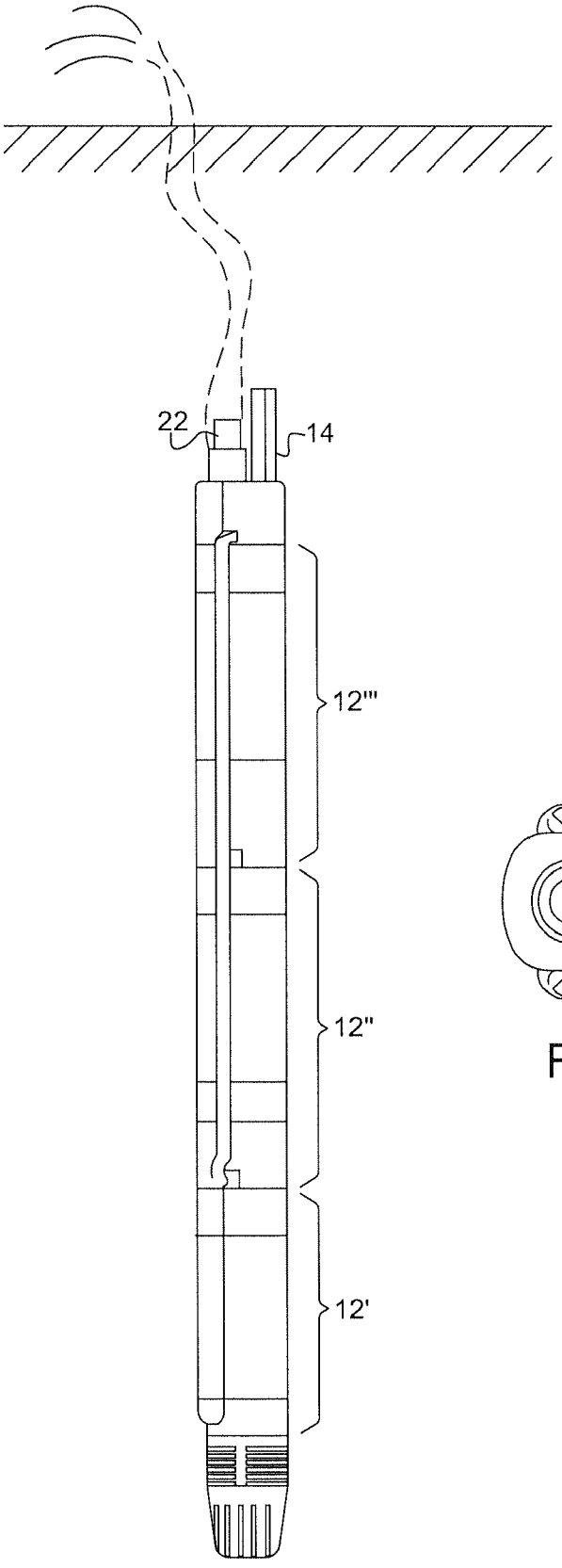


FIG. 2

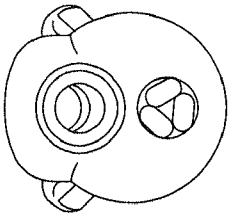


FIG. 5

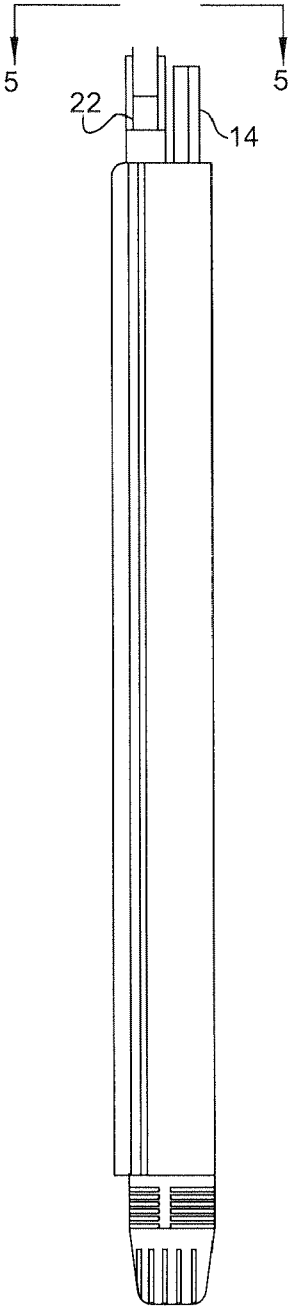


FIG. 3

GROUNDWATER SAMPLING DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a non-provisional claiming domestic benefit of provisional application No. 60/992,248 filed Dec. 4, 2007 and provisional application No. 61/051,527 filed May 8, 2008, the entire disclosures of which are herein incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates generally to systems and methods for gathering liquid samples using a submersible pump placed into a pre-established well for analysis and/or groundwater removal and groundwater remediation and circulation of fluids, and more particularly to a device and system for these purposes with includes a centrifugal pump which is sized to fit into a well of 1.5 inches, or less, such as a well having an inner diameter of one inch, or less, and capable of sending a water sample upwards of 30 feet for collection and/or analysis.

[0004] 2. Description of Related Art

[0005] The taking of groundwater samples from a pre-established well for the purpose of groundwater sampling and/or removal is well known. These samples are typically taken by a submersible pump device which is descended into the well as supported and controlled by electrical power conduits and a flexible fluid conduit for conveying groundwater up to the ground surface by the pump device for removal or analysis.

[0006] A number of prior art devices are known to applicant which are disclosed in the following U.S. patents:

[0007] U.S. Pat. No. 5,238,060 to Niehaus, et al.

[0008] U.S. Pat. No. 6,158,509 to Peterson

[0009] U.S. Pat. No. 5,708,220 to Burge

[0010] U.S. Pat. Re. 34,754 to Dickinson, et al.

[0011] U.S. Pat. No. 5,220,820 to Manke, et al.

[0012] U.S. Pat. No. 6,758,273 to Learned

[0013] U.S. Pat. No. 7,252,141 to Intelisano

[0014] U.S. Pat. No. 5,238,060 to Niehaus discloses a fluid sampling apparatus for withdrawing samples of groundwater or other fluids. The pump includes a packer associated therewith which minimizes the amount of liquid which must be pumped to purge the well prior to obtaining an acceptable sample.

[0015] A method and apparatus for gathering liquid samples using a submersible pump is further disclosed by Peterson in U.S. Pat. No. 6,158,509. The submersible pump is operated by means of a surface valving system and solenoid systems mounted on the submersible pump. U.S. Pat. No. 5,708,220 to Burge teaches a liquid sampling device comprising a submersible liquid sampling device and a ground level sample receiving and control facility.

[0016] Dickinson, et al., in U.S. Pat. Re. 34,754 discloses a fluid sampling apparatus for withdrawing samples of groundwater or other fluids from a well or other monitoring site, said apparatus comprising a pump means, conduit means and a wellhead assembly. U.S. Pat. No. 5,220,829 to Manke, et al. teaches a down hole formation test pump including a progressive cavity pump and Learned discloses methods, apparatus and a low-flow groundwater sampling system in U.S. Pat. No. 6,758,273.

[0017] My previous U.S. Pat. No. 7,252,141 discloses a pump having a replaceable motor. Each of the disclosures of these patents is herein incorporated by reference,

[0018] The present invention provides such a groundwater sampling device and system for withdrawing groundwater from a pre-established well having an inner diameter (ID) not exceeding 1.5 inches, typically not exceeding an ID of 1.0 inches which device is readily insertable and removable from such a small well and can lift a sample at least 30 feet, and up to or exceeding 200 feet, for collection and/or analysis. The pump must obviously be smaller than the ID of the well to assure insertion and removal. Thus, I have found that a pump of an outer dimension (OD) of about 1.4 inches is sufficiently small enough to use with a 1.5 inch ID well, and a pump of an OD of less than about 0.8 inches, e.g. preferably an OD not greater than 0.75 inch is sufficiently small to use with an 1.0 inch ID well.

[0019] Heretofore, only peristaltic pumps were capable of obtaining a sample from small wells but they were limited by lifting the sample not more than 25 feet. The inventive pump is the first centrifugal pump capable of being inserted into the well having an ID of not more than 1.5 inches and lifting a sample at least 30 feet, and no one has heretofore lifted a sample from a 1.0 inch well more than 30 feet with a pump small enough to fit with the ID of a 1.0 inch well.

BRIEF SUMMARY OF THE INVENTION

[0020] This invention is directed to a groundwater sampling and pumping device and system for withdrawing groundwater from a well. The device includes a hollow outer housing having water inlet ports formed near a bottom thereof and an integral hollow conduit sized to be positioned as part of the outer housing and defining a water flow passage therethrough. An electric motor in the inner housing is connected to a water impeller operably positioned to draw groundwater into the water passage. The water passing upwardly through the integral hollow conduit can be carried directly to the surface through a flexible pipe or tube or into another stage of the pump for further increasing the pressure of the water.

[0021] It is therefore an object of this invention to provide a groundwater sampling device for withdrawing groundwater from a pre-established well of small ID which is readily insertable and removable from the well and can lift a sample a minimum of 30 feet.

[0022] It is still another object of this invention is to provide a high quality and high lifting capacity groundwater sampling device and system for withdrawing groundwater from a pre-established well of small ID and which includes an integral water passage for water flow around the motor for heightened cooling and increased motor longevity.

[0023] Yet another object of this invention is to provide a groundwater sampling device for pumping groundwater from a pre-existing well of small ID which is capable of lifting a water sample at least 30 feet from a single stage pump, but which can be combined into a multi-stage pump having a greater lifting capacity in a small ID well.

[0024] In accordance with these and other objects, which will become apparent hereinafter, the instant invention will now be described with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0025] FIG. **1** is a simplified front view of the groundwater sampling device of the invention.

[0026] FIG. **2** is a right side view of the device of FIG. **1**.
[0027] FIG. **3** is a left side view of the device of FIG. **1**.
[0028] FIG. **4** is a partial cross sectional view of a typical first stage of the device of FIG. **1**.
[0029] FIG. **5** is a top view of the groundwater sampling device of FIG. **3**.

DETAILED DESCRIPTION OF THE INVENTION

[0030] Referring now to the drawings, and firstly to FIGS. **1**, **2** and **3**, the groundwater sampling device is shown in FIG. **1** generally by numeral **10** and includes a water sampling device **12** in the form of a submersible groundwater pump, an electrical conduit **14** which interconnects a voltage controller/booster device **16** to the device **12** and further includes a collector (not shown) into which the groundwater is pumped out of a pre-established well of small internal ID (not greater than 1.5 inches) through a water conduit **22** for collection and/or analysis.
[0031] The device **12** is described in more detail hereinbelow and is positionable within the well formed into the ground below grade level. The depth to which the device **12** descends is controlled primarily by the feeding of the electrical conduit **14**. An optional system voltage/current controller/booster **16** as will be further discussed below includes a connection to the electrical conduit **14**. Electrical contacts **34**, which are attachable to the terminals of a low voltage D.C. electrical power source, such as a 12 volt battery, provide the power input into the electric motor **48** and/or controller **16**. By the adjustment of a variable voltage adjuster, which can be monitored by a liquid crystal display, voltage output from the controller **16** into the motor contained within the device **12** can thereby be provided. Controller **16** can be used to adjust the voltage applied to the DC voltage driven electric motor **48** (FIG. **4**). Electric motor **48** is designed to operate between 0 and 39 VDC and can thus be powered by typical power supply of a vehicle battery (12V) adjusted down or up to 39 volts by controller **16**. Amperage may also be controlled by controller **16**.
[0032] The controller **16** inputs direct current from the 12-volt battery and produces an output voltage to run the device **12** within the specified parameters. In one embodiment, the controller **16** boosts the voltage to a fixed 39 volts and then, using a buck converter, puts out a selected fixed voltage to the pump to operate the device **12** at the selected parameters. Consideration is given to the effective wire loss to maximize water output or pressure head that can be pumped. In some circumstances known as a low flow sampling, the motor **48** will be able to pump at very low voltages near 0 volts. In such circumstances it is preferred to employ as controller **16** a low flow sampling controller.
[0033] Still referring to FIG. **1**, when the sampling device **12** is activated, groundwater is forced upwardly through hollow conduit **22** and then through a flexible conduit **24** for dispersion of a controlled volume of groundwater into a collection vial (not shown). Alternatively, the device **10** may also be used to simply evacuate groundwater from a pre-established well in which case the upper end of the flexible conduit **24** is directed to discharge the groundwater into a suitable container, above ground basin or the like.
[0034] Referring now to FIG. **4**, the preferred groundwater sampling device **12**, as best seen collectively in FIGS. **1-4**, may be viewed and best understood in their separate component stages, most of which are generally formed of substantially noncorrosive materials, such as a polymeric material which may be a homopolymer, copolymer or blend for strength. Other materials of construction can be employed, such as stainless steel and/or polytetrafluoroethylene (available under the trademark TEFLON®) as very high quality materials for device **12**. As seen in FIG. **4** in which a partial cross section is shown, an outer cylindrical housing **40** formed of a polymeric material (or stainless steel or other materials) is hollow on the interior thereof, includes a matable bottom **42** threadably engaged into the tubular material which is formed as an attached nose having water inlet ports **44** formed therethrough as also best shown in FIG. **4**. These inlet ports **44** lead to an interior chamber **86** into which groundwater is drawn in the direction of arrows A in FIG. **4**. When employing pumps small enough to enter into a 1.0 inch ID well it is most preferable that the greatest strength of the housing be made with the thinnest cross-section of tubing possible. Thus, stainless steel or other high strength metallic alloys are preferred for the housing of pumps small enough to fit into a 1.0 inch ID well.
[0035] In FIG. **4**, the inner hollow cylindrical tubular housing **46**, also formed of polymeric, stainless steel, or other material, includes a bottom **46** having a water seal **80** disposed and having an axial passageway to receive an output shaft **52** of a D.C. motor **48** sealingly fit there-through upon motor **48** insertion into the inner housing **46**. A water impeller **50** is attached to the output shaft **52** and is positioned (as best seen in FIG. **4**) within the interior chamber **86**. A hollow gap is established by the spacing between the inner diameter of the outer housing **40** and the outer diameter of the inner housing **46** to define a water passage **88** which upwardly receives groundwater in the direction of the arrows caused to flow into the inlet ports **44** in the direction of arrow A, continuing through the interior chamber **86**, again in the direction of the arrows into the water passage **88**.
[0036] The upper end of the motor **48** includes two electrical contacts **56** and **58** which receive electrical D.C. current and voltage either directly from a power source or optionally from the controller **16** through the electrical conduit **14** as will be described in more detail hereinbelow. The preferred motor operating parameters are from 12.6 to 17.4 VDC, more preferably 12.6 and 16.4 VDC, but as stated above the motor is designed to operate between 0 and about 39 volts D.C.
[0037] Note that the flow of water though water passage **88** cools the motor **48** for increasing motor life and efficiency.
[0038] Although, I have described my invention with regard to use in a well not exceeding 1.5 inch ID, preferably not exceeding 1.0 inch ID that is only illustrative of the invention and my invention could be used in a well having smaller than 1.0 inch ID provided the maximum exterior dimensions of device **12** are reduced to fit with such wells.
[0039] Referring now to FIGS. **1-3**, an alternative embodiment of the sampling device having a single stage will be explained with regard to a multi-stage device, which includes the components previously described in connection with FIG. **4**, except as noted hereinbelow. However, in these embodiments, multi-stage pumps are provided to increase the water pressure, and thus the height to which they are capable of lifting the water.
[0040] Although I have illustrated three stages at **12'**, **12"** and **12'"**, it should be understood that fewer or more stages can be provided to achieve the desired pressure (and have the required lifting height) of a groundwater liquid to 200 feet, or more.

[0041] In this embodiment the groundwater entering the first stage from the well is pumped through water passage **88** and then into a second stage **12"** where another impeller further acts upon the groundwater, thereby increasing its pressure and delivering it to a third stage **12'"**, where the process is repeated. The device **12** may be provided with sufficient stages to lift the groundwater sample to the desired height. In a particularly preferred embodiment of the pump fitting within a well of one inch ID, 24 stages have been employed.

[0042] While the instant invention has been shown and described herein in what are conceived to be the most practical embodiments, it is recognized that departures may be made therefrom within the scope of the invention, which invention is therefore not to be limited to the details disclosed herein, but is to be afforded the full scope of the claims so as to embrace any and all equivalents thereof.

I claim:

1. A groundwater sampling and centrifugal pump device comprising a hollow outer housing having water inlet ports near a bottom thereof and an integral hollow conduit sized to be positioned as part of the outer housing;

an inner housing sized and shaped to receive a DC electric motor therein;

said motor having a downwardly extending shaft;

said shaft carrying an impeller to move the water from the inlet ports through said integral hollow conduit;

said maximum outer diameter of the outer housing being smaller than the inner diameter of 1.5 inches of a well;

said device being capable of lifting groundwater to a height of at least 30 feet.

2. The device of claim **1**, further including a voltage/current controller/booster electrically connected to said motor to provide a power input to the motor from 0 to 39 V DC.

3. The device of claim **1**, wherein the hollow conduit is positioned adjacent to the inner housing containing the water to provide cooling to the motor.

4. The device of claim **1**, wherein the inner and outer housings are made of at least one material selected from the group consisting of polymeric material and stainless steel.

5. The device of claim **1**, further comprising a seal between the shaft and the inner housing.

6. The device of claim **1**, further including a flexible conduit connected to said integral hollow conduit to convey water above the ground level in which the well is situated.

7. The device of claim **1**, further including at least one additional pumping stage and the hollow conduit conveys water to the at least one additional stage.

8. The device of claim **7**, wherein there are at least three stages to which water is conveyed before being discharged to above the ground level.

9. The device of claim **1**, coupled to an electric conduit.

10. The device of claim **9**, wherein the electrical conduit is electrically connected to a low flow sampling controller.

11. A method of conveying ground water from a well having a maximum inner diameter (ID) of 1.5 inches comprising lowering a centrifugal pump having a DC powered electric motor into said well until it contacts said groundwater;

supplying DC voltage to the electric motor causing rotation of an impeller to cause flow of water through an integral hollow conduit adjacent to a housing in which the motor is contained;

and simultaneously cooling the motor and conveying the groundwater above the level of the ground in which the well is situated.

12. The method of claim **11**, in which the groundwater is conveyed upwardly to a distance of more than 30 feet.

13. The method of claim **12**, wherein the distance is more than 200 feet.

14. The method of claim **11**, wherein the groundwater passes through at least a second stage of the pump before it reaches the level of the ground in which the well is situated.

15. A method of conveying groundwater from a well having a maximum inner diameter of 1.5 inches by increasing a centrifugal pump in said groundwater, emerging the pump through a DC motor and lifting the groundwater at least 30 feet.

16. The method of claim **15**, wherein the groundwater is lifted between 30 and 200 feet.

17. The method of claim **15**, wherein the groundwater is lifted at least 200 feet.

18. The method of claim **15**, wherein the centrifugal pump is a single stage pump.

19. The method of claim **16**, wherein the centrifugal pump is a multi-stage pump.

20. The method of claim **11**, wherein the housing is made of polymeric material and/or stainless steel.

21. The device of claim **1**, wherein the pump has an outer housing of not greater than 0.8 inch.

* * * * *