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|---|---|
| <p>(51) International Patent Classification:
 <i>G01F 15/00</i> (2006.01) <i>G01F 1/44</i> (2006.01)
 <i>G01F 1/36</i> (2006.01) <i>G01F 1/075</i> (2006.01)</p> | <p>(72) Inventors; and
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| <p>(21) International Application Number:
 PCT/US2009/052426</p> | |
| <p>(22) International Filing Date:
 31 July 2009 (31.07.2009)</p> | |
| <p>(25) Filing Language:
 English</p> | |
| <p>(26) Publication Language:
 English</p> | |
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[Continued on next page]

- (54) Title:** SELF-CALIBRATING AND SELF-POWERED WATER METER

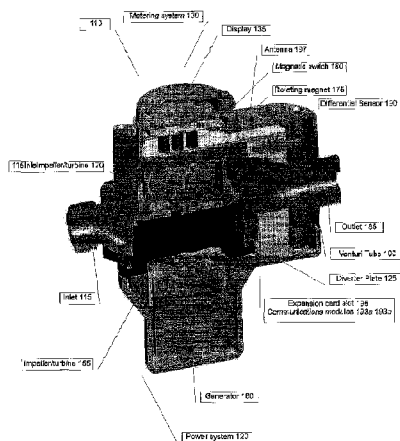


Fig. 2

(57) Abstract: A meter includes an inlet for receiving a fluid and a first chamber housing defining a first chamber to receive the fluid from the inlet and a first port for transmitting the fluid from the first chamber, wherein the first chamber is utilized to generate power for the meter. The meter also includes a second chamber housing defining a second chamber to receive the fluid from the first port, wherein the second chamber is utilized to meter fluid, and an outlet coupled to the second chamber.

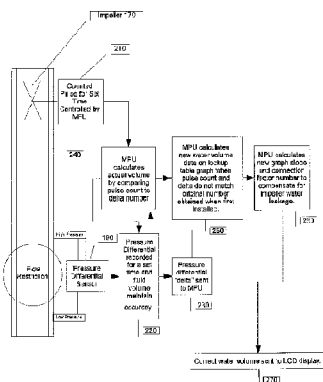


Fig. 4



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(81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH,

GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

SELF-CALIBRATING AND SELF-POWERED WATER METER**TECHNICAL FIELD**

[0001] The present invention relates in general to meters, and more specifically, to self-calibration and power generation in fluid meters.

BACKGROUND

[0002] Fluid meters are utilized to measure volume of fluid usage. For example, in some countries, water meters are used at each residential and commercial building in a public water supply system. To the extent that conventional utility meters can transmit usage data, these meters are typically capable of transmitting data only relatively infrequently due to power issues and other constraints. For example, this transmission distance is generally limited, requiring field technicians to either read the meter directly or from a relatively short distance away.

[0003] After 3-5 years of operation, wear and tear may require meters to be recalibrated. Worn meters may over or under read the amount of fluid passing through the meter and it may require significant effort and expense to systematically check and calibrate individual meters in a given service area.

SUMMARY

[0004] Accordingly, a meter includes an inlet for receiving a fluid and a first chamber housing defining a first chamber to receive the fluid from the inlet and a first port for transmitting the fluid from the first chamber, wherein the first chamber is utilized to generate power for the meter. The meter also includes a second chamber housing defining a second chamber to receive the fluid from the first port, wherein the second chamber is utilized to meter fluid, and an outlet coupled to the second chamber.

[0005] Another embodiment provides a fluid metering system including an inlet, a power generation chamber, wherein a turbine is positioned in the power generation chamber, and a generator coupled to the turbine. The fluid metering system also includes a metering chamber, wherein an impeller is positioned in the metering chamber, a diverter plate separating the power generation chamber and the metering chamber, a sensor coupled to the impeller, an outlet coupled to the metering chamber, a flow restrictor positioned within the outlet from the metering chamber, and a pressure differential sensor coupled to the flow restrictor.

[0006] Yet another embodiment provides a method for metering fluid. The method includes receiving fluid from an inlet in a power generation chamber, wherein the fluid causes a turbine to rotate, and utilizing the rotation of the turbine to generate power in a generator. The method also includes receiving fluid in a metering chamber, wherein the fluid causes an impeller to rotate, counting a number of rotations of the impeller, and calculating a pulse flowrate based on a number of rotations detected.

[0007] The foregoing has outlined some of the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The foregoing and other features and aspects of the present invention will be best understood with reference to the following detailed description of a specific embodiment of the invention, when read in conjunction with the accompanying drawings, wherein:

[0009] **Figure 1** is an illustration of a system for fluid distribution management;

[0010] **Figure 2** is an illustration of fluid meter providing self-calibration and power generation;

[0011] **Figure 3** is an illustration of a lower chamber of a fluid meter;

[0012] **Figure 4** is an illustration of a self-calibration process;

[0013] **Figure 5** is a flow chart illustrating a self calibration procedure for a meter; and

[0014] **Figure 6** is an illustration of a charging system.

DETAILED DESCRIPTION

[0015] Refer now to the drawings wherein depicted elements are not necessarily shown to scale and wherein like or similar elements are designated by the same reference numeral through the several views.

[0016] Figure 1 is an illustration of a system for water distribution management, indicated generally at 10. System 10 includes fluid utility grid 15 for the distribution of fluid to clients 45, e.g., households and businesses within a service area. Water utility grid 15 may include water treatment plants 20, water storage 25, pumping station 85 and other facilities suitable for receiving, treating, storing and distributing water throughout the service area. Water utility grid 15 distributes water to client 45 via utility line 30 and client line 40.

[0017] System 10 includes a fluid meter, such as water meter 35. Water meter 35 comprises a valve (not shown in FIG. 1) or similar device to regulate water flow to client 45 from utility line 30. Water meter 35 is operable to determine the water usage of client 45 and control valve functions to shut water off or turn water on for client 45. System 10 includes wireless network 70. Water meter 35 may send and receive data via wireless network 70. Wireless network 70 may be any public, private or proprietary network, for instance. Wireless network 70 may include, for example, cellular, Wi-Fi, Wi-Max, 400 MHz, 900 MHz, proprietary radio network protocols, or any other type of wireless communications protocol.

[0018] System 10 includes network operations center 50 to manage and monitor the distribution of water utilities in system 10. Network operations center 50 may be operated by a water utility

company, for example. Network operations center 50 includes a wireless communications transmitter/receiver 55 to send and receive data over wireless network 70. Network operations center 50 includes one or more servers 60 to manage data transmission through system 10. For example, transmitter/receiver 55 may receive radio frequency (RF) signals via wireless network 70 and convert these signals to Internet Protocol (IP) signals, or other suitable network protocol, for transmission to server 60, or other components of system 10. Network operations center 50 may also include database 65 to store data concerning client fluid usage and service area fluid usage, among other information.

[0019] Network operations center 50 may receive data from water meter 35 concerning the fluid usage of client 45. For example, operation center 50 may receive usage alarms, notices, and the like. Moreover, network operations center 50 may send data or instructions to water meter 35. System 10 may include one or more mobile field technicians 75 to facilitate data collection and transmission throughout the service area associated with system 10. For example, network operations center 50 may send data to and receive data from water meter 35 via mobile field technician 75. Mobile field technicians 75 may include transmitter/receivers 75a, portable computers 75b, and cell phones or personal digital assistants (PDA) 75c, for example, to communicate with water meter 35 and wireless network 70.

[0020] System 10 may also allow communication with client 45 concerning the status or usage of the water utility. For example, network operations center 50 may transmit e-mail correspondence to client 45 regarding alerts or notices. For example, if network operations center 50 receives data indicating a potential water leak, network operations center 50 may

request that client 45 verify whether a water leak has been observed. If the service area is subject to water rationing or similar form of controlled distribution, for instance, network operations center 50 may provide a notice to client 45 concerning the remaining amount of water client 45 is allowed to use for a given rationing period.

[0021] System 10 may include one or more emergency response centers 80. Emergency response center 80 may be any city, state or federal government agency responsible for responding to emergencies and with authority to redirect or shut off utilities based on the circumstances, e.g., natural disasters or contamination, for example. For example, emergency response center 80 may include local fire departments, the Federal Emergency Management Agency (FEMA), the United States Department of Homeland Security (DHS), or similar entities. Network operations center 50 may communicate with emergency response center 80, via wireless network 70, for example, and manage the distribution of utilities throughout system 10 in accordance with instructions received from emergency response center 80.

[0022] Figure 2 is an illustration of fluid or water meter 35 providing self-calibration and power generation. Meter 35 may include inlet 115, power system 120, diverter plate 125, metering system 130, display 135, and outlet 140. Fluid, such as water, enters meter 35 through inlet 115 and flows into lower chamber 150. While embodiments discussed herein may specifically refer to water when discussing meter 35, it should be noted that any suitable fluid may be utilized with meter 35.

[0023] Power system 120 includes lower chamber 150, turbine or impeller 155, generator or alternator 160, and battery system (not shown). Any reference to a battery system also refers to a

power storage device. Power system 120 is utilized to generate and store power for meter 35. Fluid entering lower chamber 150 causes turbine 155 to rotate. Turbine 155 may utilize straight blades or curved blades. In some embodiments, lower chamber 150 may include a jet 152 to help power turbine 155 as shown in Figure 3. As fluid enters lower chamber 150 through jet 152, it transfers mechanical energy to turbine 155 and moves towards the center of lower chamber 150. Generator 160 is coupled to turbine 155 and converts the mechanical energy of the fluid flow into electrical energy. For example, generator 160 may be an electric power generator, a Tesla turbine, or the like. Electrical energy harnessed by generator 160 may be utilized to provide charge current to a battery system and/or to power to components of meter 35. In some embodiments, a magnetic coupler may be utilized to magnetically couple turbine 155 and generator 160. In one embodiment, generator 160 may be capable of generating power at low RPM, such as about 100 RPM. For example, the design of various components of meter 35 may allow charging at low RPM, such as the design and shape of inlet 114, jet 152, turbine 155, diverter plate 125, and the like. Further, electrical components (e.g. generator 160, battery, charging circuit, and other power components) may be capable of generating sufficient power for charging at low RPMs.

[0024] Metering system 130 includes upper chamber 165, turbine or impeller 170, rotating magnet 175, magnet switch 180, a flow restrictor 185, pressure differential sensor 190, and outlet 140. Upper chamber 165 is separated from lower chamber 150 by one or more diverter plates 125. Plate(s) 125 act as a baffle to fluid traveling from lower chamber 150 to upper chamber 165 and may thereby reduce turbulence. Because turbulence causes inconsistent flow or fluctuations in the flowrate, plate(s) 125 may increase the accuracy of the metering system 130 by reducing

turbulence. One or more plates 125 may include directional fins that are utilized to establish a consistent rotational flow that drives impeller 170. As fluid flows through upper chamber 165, the flow causes impeller 170 to rotate. As with turbine 155, impeller 170 may utilize straight or curved blades.

[0025] Fluid flowing from lower chamber 150 into upper chamber 165 may cause impeller 170 to rotate. As impeller 170 rotates, rotating magnet 175 causes magnetic switch 180 actuate. Each actuation of magnetic switch 180 creates a pulse that indicates a precise amount of fluid metered through metering system 130. For example, the blades of impeller 170 may force out a precise amount of fluid during each rotation. In other embodiments, rotating magnet 175 and switch 180 may be substituted with an alternative system for detecting the number of rotations of impeller 170, such as an inductive pickup, Hall effect sensor, optical sensor, or any other suitable sensor(s).

[0026] As fluid flows out of upper chamber 165 towards outlet 140, it passes through flow restrictor 185, such as a Venturi tube or an orifice plate. Venturi tube 185 includes pressure differential sensor 190 that provides a precision voltage output, representing the pressure difference detected, when fluid passes by sensor 190 that is utilized to calculate the amount of fluid metered through metering system 130.

[0027] Water meter 35 may also include primary wireless communications module 193a, which may be communicatively coupled to water meter 35 via an expansion card slot 195. Primary wireless communications module 193a may comprise any module operable to support two-way communication over a wireless network. For example, primary wireless communications

module 193a may include a plug-in radio communications card to support cellular, Wi-Fi, Wi-Max, 400 MHz, 900 MHz or proprietary radio network protocols, among other wireless protocols. Water meter 35 may also include backup wireless communications module 193b in the event that primary wireless communications module 193a becomes inoperable or the communications network for primary wireless communications module 193a goes down. Backup wireless communications module 193b preferably uses a different communications protocol than module 193a, e.g., communicates via a different network, to provide greater reliability or emergency response. Water meter 35 may include additional expansion card slots 195 to allow for additional wireless communications modules. Water meter 35 may include an antenna 197, e.g., coupled to communications modules 193a and 193b, for example, to facilitate wireless communication.

[0028] Figure 4 is an illustration of a self-calibration process 200. As discussed previously, as fluid flows through fluid meter 35, pulses from impeller 170 are detected and a pressure drop through flow restrictor 185 is detected. The number of pulses detected in a set time period is counted by a processor in step 210. The number of pulses counted is utilized to calculate the flowrate of an amount or volume of fluid, such as gallons per minute, passing through meter 35. In some embodiments, the processor may utilize a lookup table that provides flowrate associated with the number of pulses detected to calculate the volume of fluid passing through meter 35. The flowrate calculated utilizing the number of pulses is herein referred to as the pulse flowrate or pulse GPM (Gallons Per Minute).

[0029] Pressure differential sensor 190 produces a voltage output in accordance with a pressure drop measured through flow restrictor 185. Accurate measurement of the flow from Venturi tube 185 can be determined by measuring the pressure difference $p_1 - p_2$. A formula derived from the Bernoulli's Principle $Q = c_d A_2 [2(p_1 - p_2) / \rho(1 - (A_2 / A_1)^2)]^{1/2}$ can be used to determine the flowrate through Venturi tube 185. In the formula, Q represents the flowrate, c_d represents the discharge coefficient, A_1 and A_2 represent flow area, p_1 and p_2 represent pressure, and ρ represents density. The voltage output from sensor 190 may be recorded for the set time period in step 220 and provided to a processor in step 230. In some embodiments, the processor may utilize a lookup table that provides flowrate associated with the voltage output detected from sensor 190 to calculate the volume of fluid passing through meter 35. The flowrate determined based on the voltage output from sensor 190 is herein referred to as dif-flowrate or dif-GPM. In some embodiment, meter 35 may provide a minimum length of five times the larger diameter of Venturi tube 185 in front of a pressure measurement point to avoid turbulent flow near sensor 190.

[0030] The processor compares the values of the pulse GPM and the dif-GPM to determine if meter 35 is accurately metering in step 240, e.g. the difference between the values falls within an acceptable variance range. In some embodiment, a difference of 1% in the flowrates is acceptable. Dif-GPM and pulse-GPM may not match for various reasons. For example, impeller 170 may be either worn and fluid is leaking past it or there may be some sort of mechanical malfunction preventing impeller 170 from rotating fully with the presented fluid flow. This may cause some meters to indicate that less fluid has passed through the meter than the actual volume of fluid that has passed through the meter. However, the self calibration

feature of meter 35 is capable of detecting the inconsistent readings and providing a correction factor utilized to calculate a corrected volume that reflect the actual amount of fluid being used. In some embodiments, correction factors based on historical testing data may be provided in a correction factor table. The processor calculates a corrected fluid volume utilizing the correction factor table when pulse-GPM and dif-GPM do not substantially match in step 250. For example, the pulse-GPM is multiplied by the correction factor and time to determine a corrected volume. The processor also calculates a new graph slope and correction factor number to compensate in step 260. For example, a lookup table (e.g. pulse table or pressure differential table), for converting the number of pulses detected and/or the pressure differential measured into the amount of fluid metered, may be adjusted to provided corrected values. If the pulse GPM and the dif-GPM do not match within a desired accuracy, a corrected fluid volume is provided to display 135 in step 270. If the pulse-GPM and dif-GPM are within the desired range of accuracy, then the fluid volume detected is correct and is displayed on display 135.

[0031] Figure 5 is a flow chart illustrating an embodiment of a self calibration procedure for meter 35. In step 410, meter 35 monitors for continuous flow at a predetermined flowrate. When the predetermined flowrate has been achieved, meter 35 begins to collect data from magnetic switch 180 and pressure sensor 190 for a predetermined period of time in step 420. In one embodiment, it may be desirable to determine if magnetic switch 180 and pressure sensor 190 are detecting a constant flow rate. For example, the time between pulses from magnetic switch 180 and the voltage output from pressure sensor 190 may be monitored to ensure that the values do not vary beyond a desired percentage. Once the data is collected, a factor f is calculated by dividing the average pulse data from magnetic switch 180 by the average voltage

data from pressure sensor 190 in step 430. Factor f is compared to a factor F , representing an initial value when meter 35 was first manufactured, in step 440. In step 450, a check is performed to determine if the values of f and F match within an acceptable margin, such as $\pm 1\%$ for example. If the values of f and F do not match within an acceptable margin, then a correction factor is retrieved and a corrected flowrate is calculated in step 460. Once the corrected flowrate is determined, it is displayed in step 470. If the values of f and F do match within an acceptable margin, the calculated flowrate does not need to be corrected and it is displayed in step 470.

[0032] Figure 6 is an illustration of a charging system. Generator 160 is coupled to rectifier bridge 510, which converts the AC input into DC output. Rectifier bridge 510 is coupled to voltage regulator 520. As fluid flow through generator 160 may be constantly changing, the voltage and current produced by generator 160 may be constantly fluctuating as well. Voltage regulator 520 is utilized to provide a constant voltage to battery charger circuit 530. In one embodiment, voltage regulator 520 is a switching regulator, which provides appropriate charging voltage in situations where the voltage is changing. However, in other embodiments, voltage regulator 520 may be a linear regulator or any suitable type of voltage regulator. Processor 530 is coupled to battery charger circuit 540, battery 550, and battery temperature sensor 560. Battery charger circuit 540 is coupled to battery 550, such as a lithium ion battery, lithium ion capacitor, or any suitable rechargeable battery. Battery temperature sensor 560 is placed adjacent to battery 550 and coupled to processor 530 to monitor the temperature of the battery during charging. Processor 530 controls battery charger circuit 540 to charge battery 550 utilizing a suitable battery charge profile. A battery charge profile may refer to specifications of

a charging cycle, which may or may not adjust the voltage and/or current during charging. For example, a battery charging profile may initially charge at a higher current, but reduce the current towards the end of a battery charging cycle to preserve long term battery life. In some embodiments, a battery charge profile may be adjusted based on the temperature of battery 550 detected by temperature sensor 560.

[0033] In addition to battery charging, processor 530 is also utilized to perform self-calibration of meter 35. Processor 530 may be coupled to one or more non-volatile memory 570. Non-volatile memory may be utilized to store firmware, programs, data, pulse tables, pressure differential tables, correction factor tables, and the like. For example, non-volatile memory 570 may store programming and data tables utilized to provide self-calibration features of meter 35 discussed herein.

[0034] The two-way communication capabilities of meter 35 may allow data stored in non-volatile memory 570 to be updated when desired. For example, data tables utilized for calibration of meter 35 may be updated, such as correction factor tables, pressure differential tables, pulse tables, and the like. Further, the two-way communication capabilities of meter 35 may allow data collected by individual meters 35 to be transmitted to a network operations center.

[0035] From the foregoing detailed description of specific embodiments of the invention, it should be apparent that a fluid meter that is novel has been disclosed. Although specific embodiments of the invention have been disclosed herein in some detail, this has been done solely for the purposes of describing various features and aspects of the invention, and is not

intended to be limiting with respect to the scope of the invention. It is contemplated that various substitutions, alterations, and/or modifications, including but not limited to those implementation variations which may have been suggested herein, may be made to the disclosed embodiments without departing from the spirit and scope of the invention as defined by the appended claims which follow.

WHAT IS CLAIMED IS:

1. A meter comprising:
an inlet for receiving a fluid;
a first chamber housing defining a first chamber to receive the fluid from the inlet and a first port for transmitting the fluid from the first chamber, wherein the first chamber is utilized to generate power for the meter;
a second chamber housing defining a second chamber to receive the fluid from the first port, wherein the second chamber is utilized to meter fluid; and
an outlet coupled to the second chamber.
2. The meter of claim 1 further comprising:
a turbine positioned in the first chamber; and
a generator coupled to the turbine.
3. The meter of claim 2 further comprising:
a charging circuit coupled to the generator; and
a battery coupled to the charging circuit.
4. The meter of claim 1 further comprising a diverter plate separating the first chamber and the second chamber.
5. The meter of claim 1 further comprising:

an impeller positioned in the second chamber; and
a sensor coupled to the impeller, wherein the sensor detects a number of rotations of the impeller.

6. The method of claim 5, wherein the sensor comprises a magnet coupled to the impeller and a magnetic switch coupled to a stationary position of the second chamber housing.

7. The meter of claim 5, further comprising:
a flow restrictor positioned within the outlet from the second chamber; and
a pressure differential sensor coupled to the flow restrictor.

8. The meter of claim 7, wherein the flow restrictor is a Venturi tube or an orifice plate.

9. The meter of claim 7 further comprising a processor, wherein the processor calculates a pulse flowrate based on the number of rotations detected by the sensor and the processor calculates a dif-flowrate based on a pressure differential detected by the pressure differential sensor.

10. The meter of claim 9, wherein the processor calculates a volume of fluid utilizing the pulse flowrate, if the pulse-flowrate and the dif-flowrate match within an acceptable variance range.

11. The meter of claim 9, wherein the processor calculates a corrected flowrate utilizing a correction factor if the pulse flowrate and dif-flowrate do not match within an acceptable variance range.

12. A fluid metering system comprising:

an inlet;

a power generation chamber, wherein a turbine is positioned in the power generation chamber;

a generator coupled to the turbine;

a metering chamber, wherein an impeller is positioned in the metering chamber;

a diverter plate separating the power generation chamber and the metering chamber;

a sensor coupled to the impeller;

an outlet coupled to the metering chamber;

a flow restrictor positioned within the outlet from the metering chamber; and

a pressure differential sensor coupled to the flow restrictor.

13. The system of claim 12 further comprising:

a charging circuit coupled to the generator; and

a battery coupled to the charging circuit.

14. The system of claim 12, wherein a processor calculates a pulse flowrate based on the number of rotations detected by the sensor and the processor calculates a dif-flowrate based on a pressure differential detected by the pressure differential sensor.
15. The system of claim 14, wherein the processor calculates a volume of fluid utilizing the pulse-flowrate, if the pulse-flowrate and the dif-flowrate match within an acceptable variance range.
16. The system of claim 14, wherein the processor calculates a corrected flowrate utilizing a correction factor if the pulse flowrate and dif-flowrate do not match within an acceptable variance range.
17. A method for metering fluid, the method comprising:
receiving fluid from an inlet in a power generation chamber, wherein the fluid causes a turbine to rotate;
utilizing the rotation of the turbine to generate power in a generator;
receiving fluid in a metering chamber, wherein the fluid causes an impeller to rotate;
counting a number of rotations of the impeller; and
calculating a pulse flowrate based on a number of rotations detected.
18. The method of claim 17 further comprising:
measuring the pressure drop across a flow restriction provided in an outlet; and

calculating a dif-flowrate based on a pressure drop measured.

19. The method of claim 18 further comprising:
comparing the pulse flowrate to the dif-flowrate; and
calculating a volume of fluid utilizing the pulse flowrate, if the pulse flowrate and the dif-flowrate match within an acceptable variance range.
20. The method of claim 19 further comprising:
calculating a corrected flowrate utilizing a correction factor if the pulse flowrate and dif-flowrate do not match within an acceptable variance range.
21. The method of claim 18, wherein the flow restriction is a Venturi tube or an orifice plate.
22. The method of claim 17 further comprising storing power from the generator in a rechargeable battery.

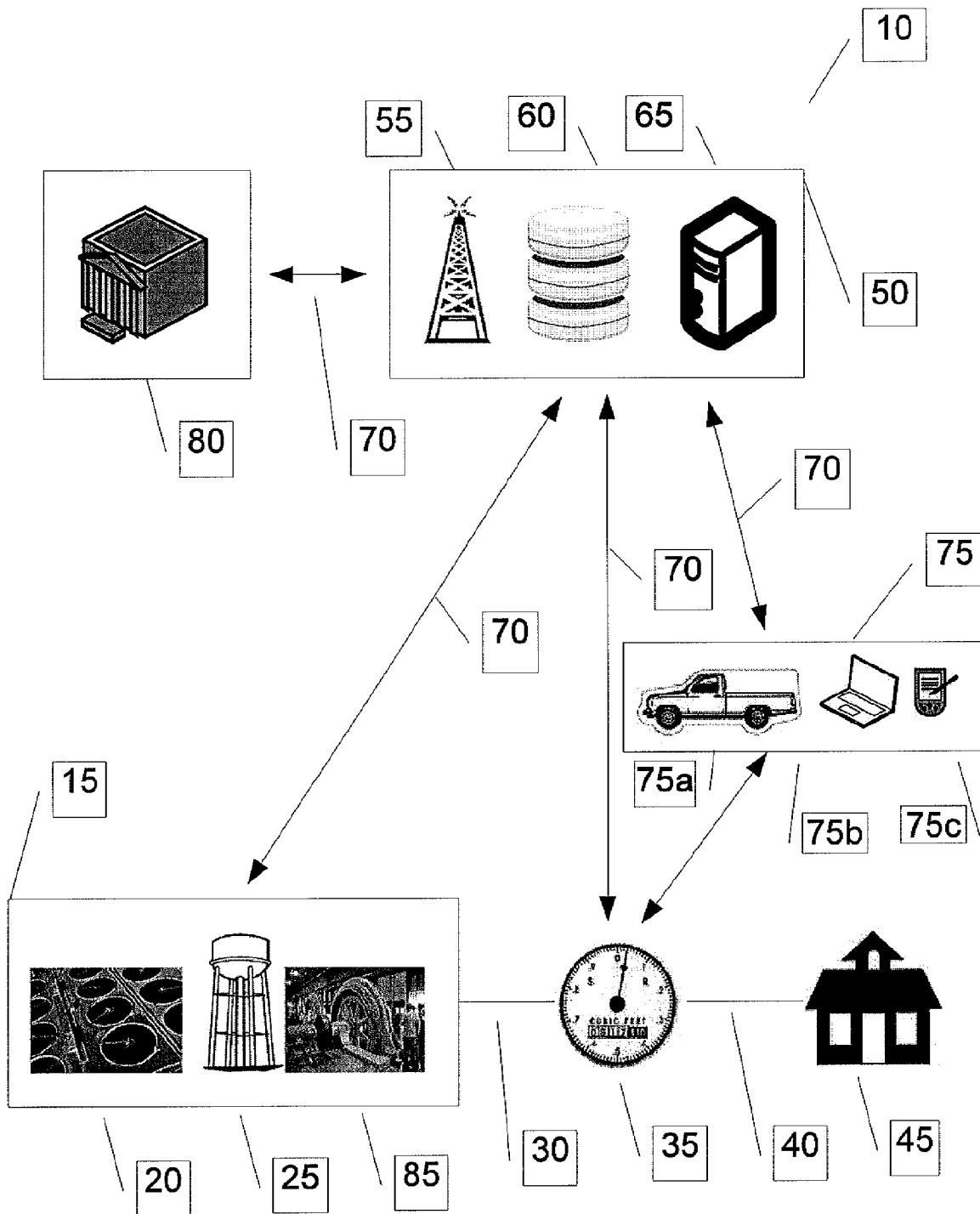


Fig. 1

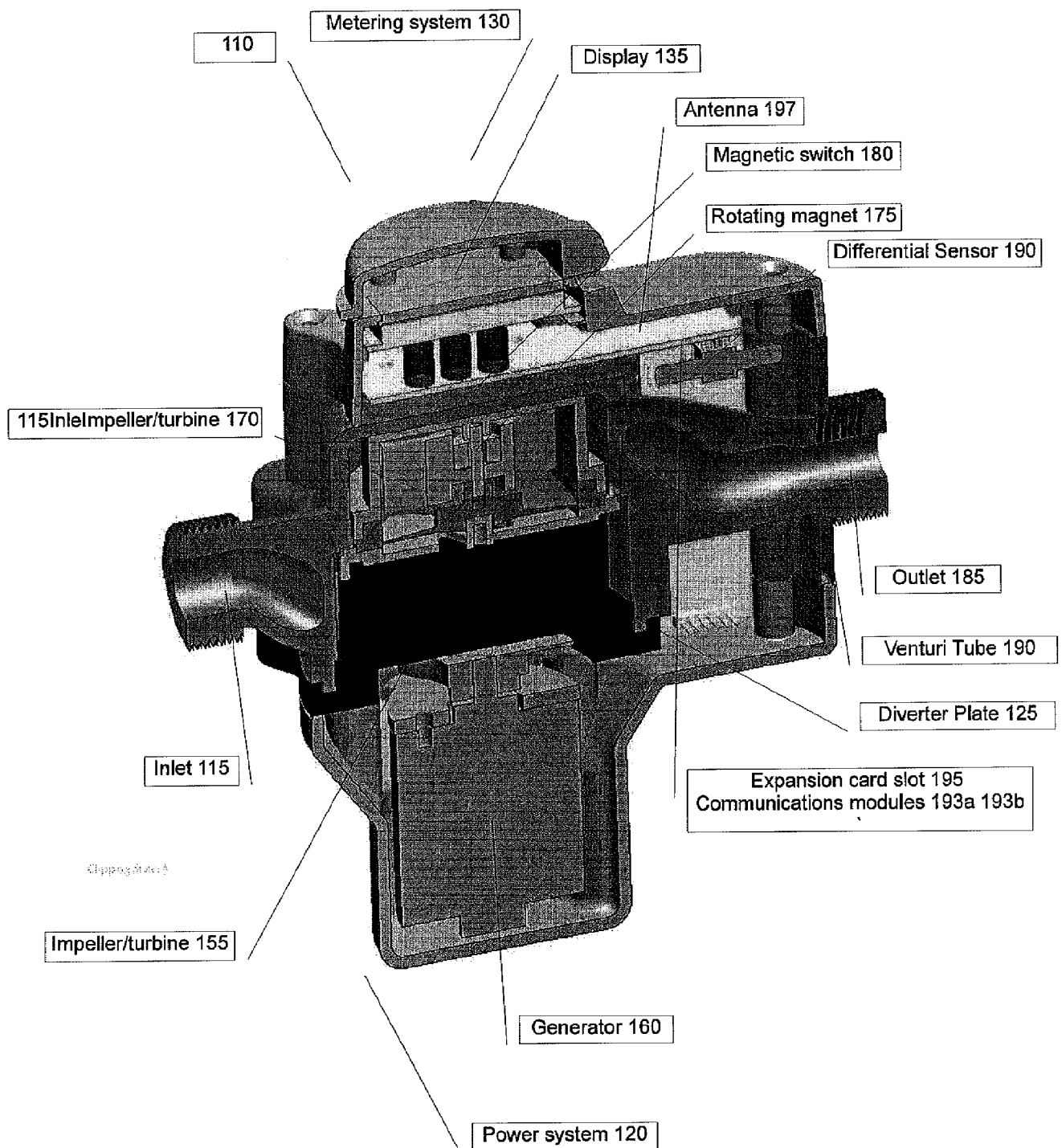


Fig. 2

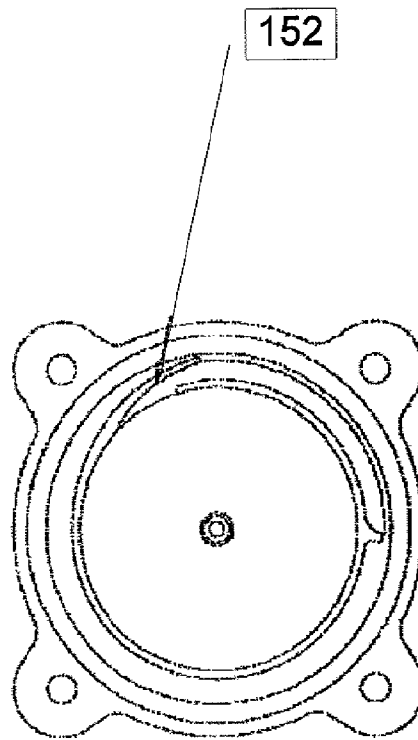


Fig. 3

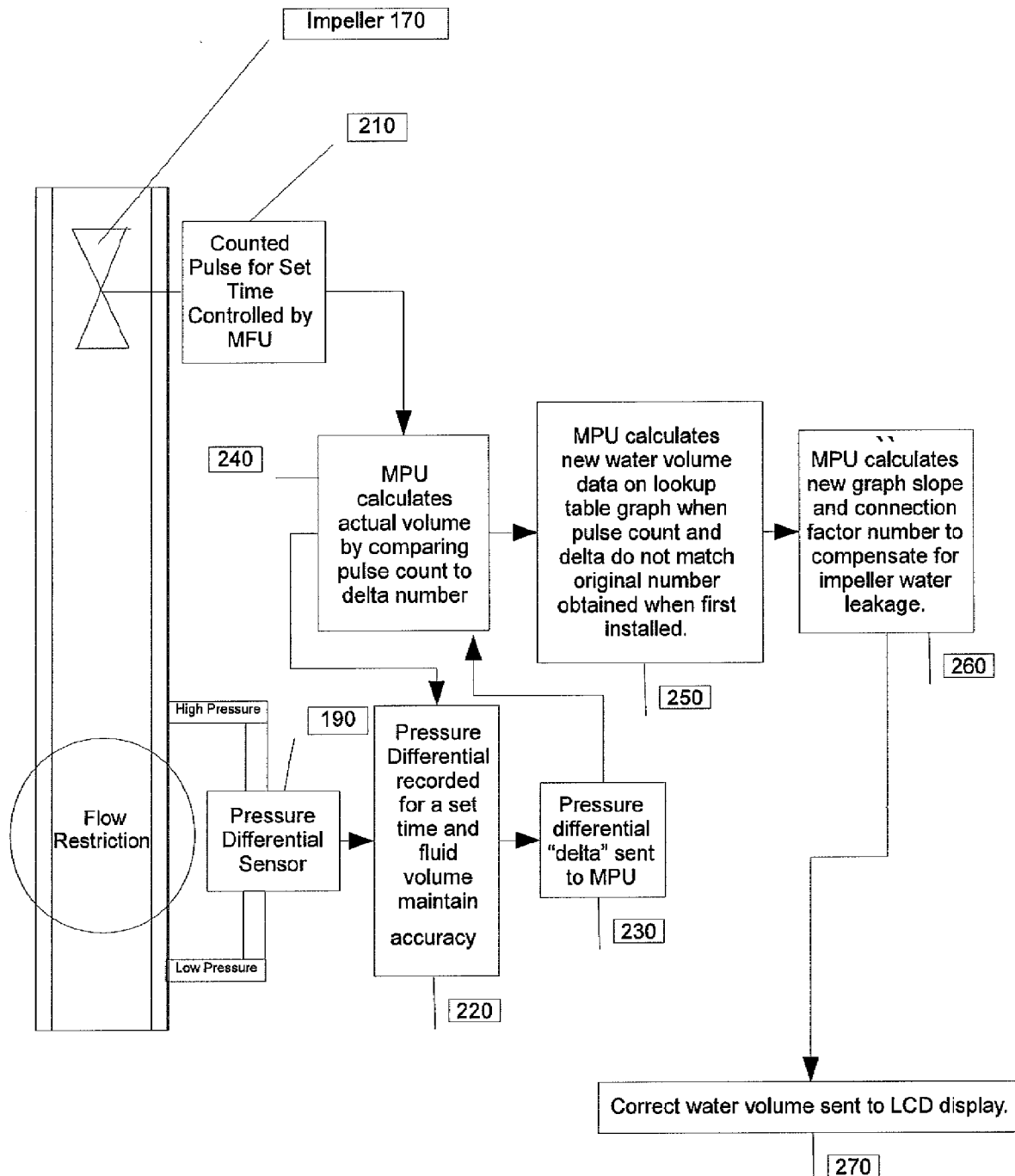


Fig. 4

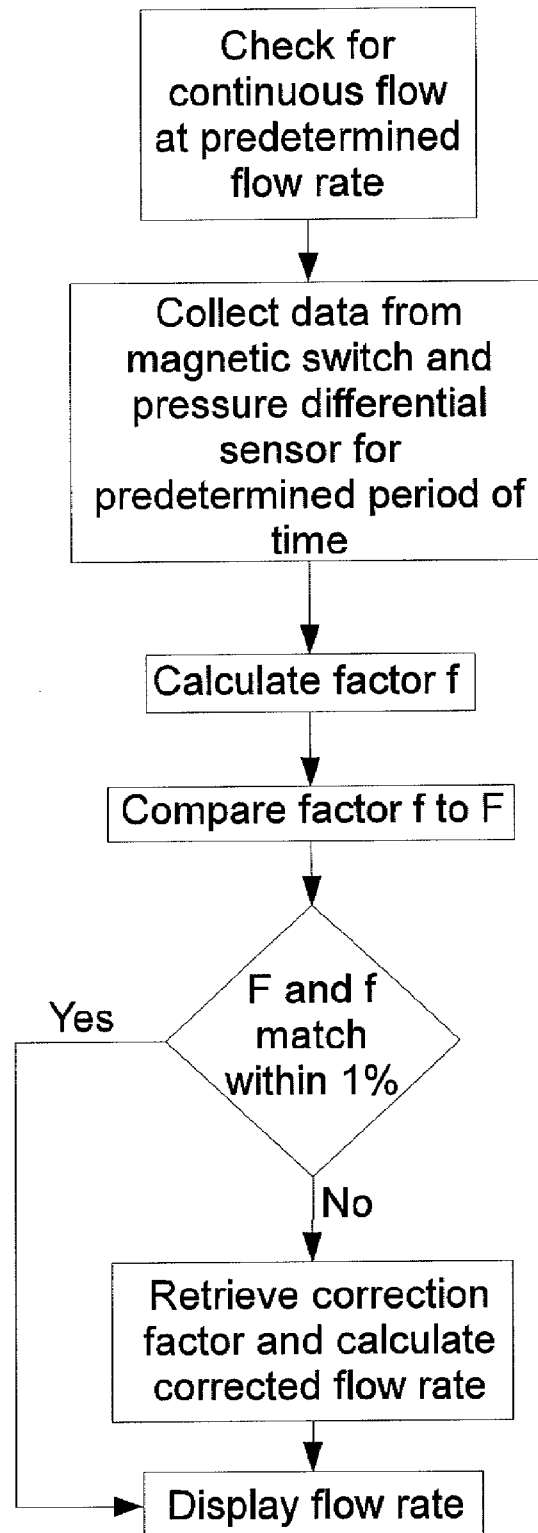


Fig. 5

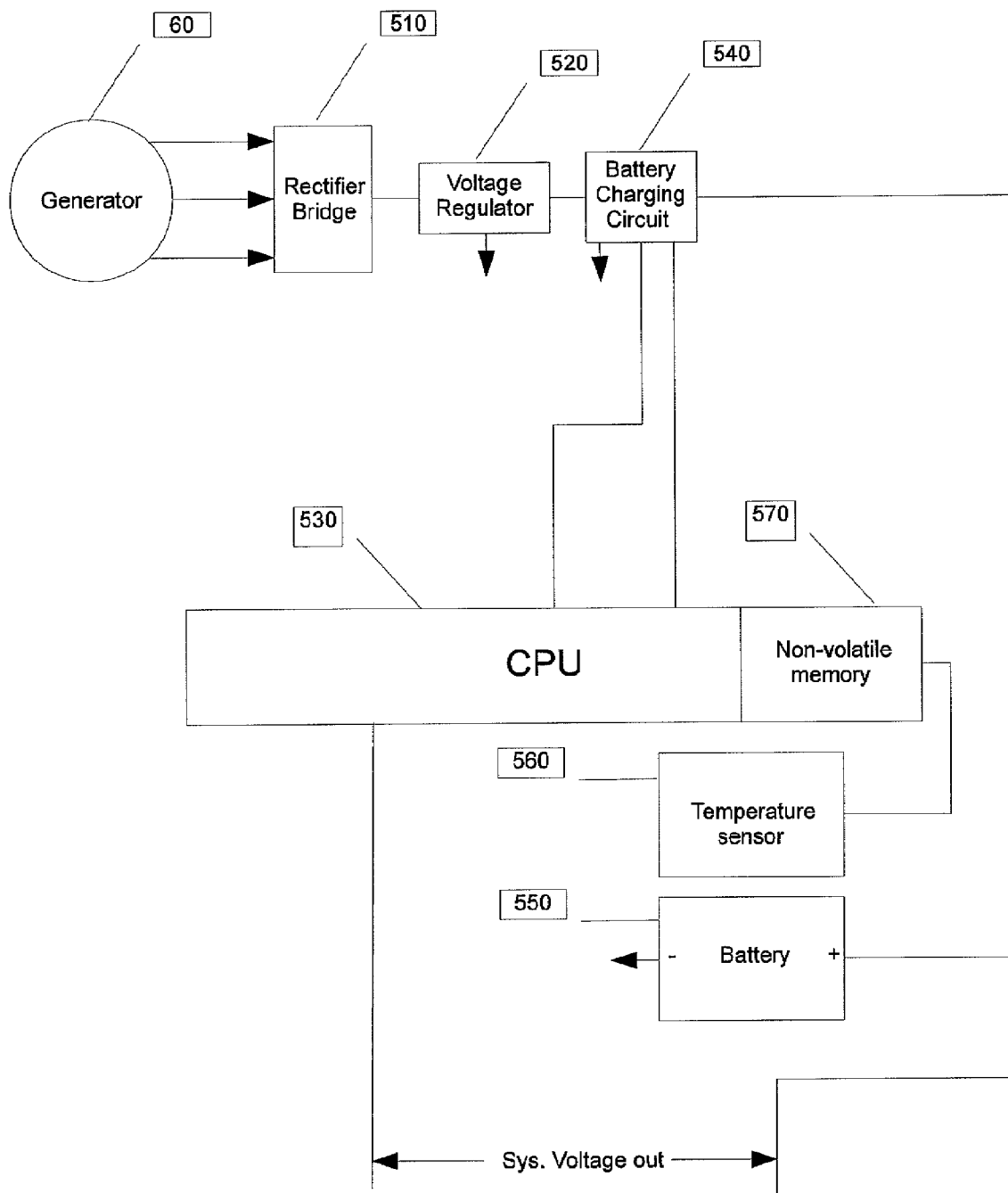


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/052426

A. CLASSIFICATION OF SUBJECT MATTER

INV. G01F15/00
ADD. G01F1/36 G01F1/44 G01F1/075

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)
G01F

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 practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01/07783 A1 (SOUTH STAFFORDSHIRE GROUP PLC [GB]; LLOYD GREGORY FRANCIS [GB]) 1 February 2001 (2001-02-01) line 8 - page 7, line 9; figures 1,2 -----	1-22
X	US 5 659 300 A (DRESSELHUYS DONN R [US] ET AL) 19 August 1997 (1997-08-19) * abstract line 46 - column 5, line 51; figure 1 -----	1-22
A	US 2002/083778 A1 (HAMILTON DAVID [US]) 4 July 2002 (2002-07-04) -----	1,12,17
A	EP 1 858 144 A2 (DRESSER INC [US]) 21 November 2007 (2007-11-21) -----	1,12,17
A	US 4 237 454 A (MEYER LESLIE D) 2 December 1980 (1980-12-02) -----	1,12,17

☐ Further documents are listed in the continuation of Box C.

☒ 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 document but published on or after the international filing date

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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.

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Date of the actual completion of the international search

12 July 2010

Date of mailing of the international search report

19/07/2010

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INTERNATIONAL SEARCH REPORT

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International application No

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