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(54) **IV INFUSION MONITORING DEVICE**

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Publication Classification

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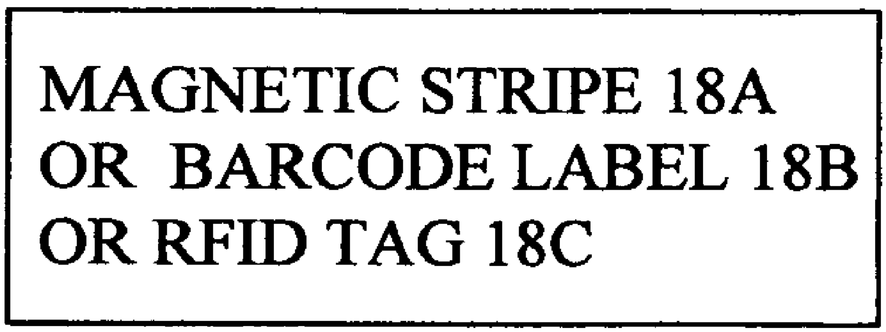
G08B 21/00 (2006.01)

(52) **U.S. Cl.** **340/613**

(57) **ABSTRACT**

An IV infusion monitoring device is provided to measure and to display, during whole infusion process, the liquid level data including the weight of remaining medical liquid in an IV bottle, the liquid flow rate and the remaining time from the completion of an IV infusion process. It also gives alarm as the medical liquid in an IV bottle drops to a predetermined low level. The IV infusion monitoring system comprises an electric load sensor, a signal processor, a monitor terminal and a power provided preferably by a battery. The load sensor measures the weight of the medical liquid in the IV bottle. The measured signal is then transmitted to the signal processor for processing and generating the liquid level data, which are then sent to the monitor terminal for display. The monitor terminal can also generate an alarm if the liquid level drops to the predetermined value. Furthermore, the monitoring device combines with a server and a plurality of PDA devices to form a communication network so that a nurse can monitor the IV infusion process from a remote location.



DATA LABEL 18

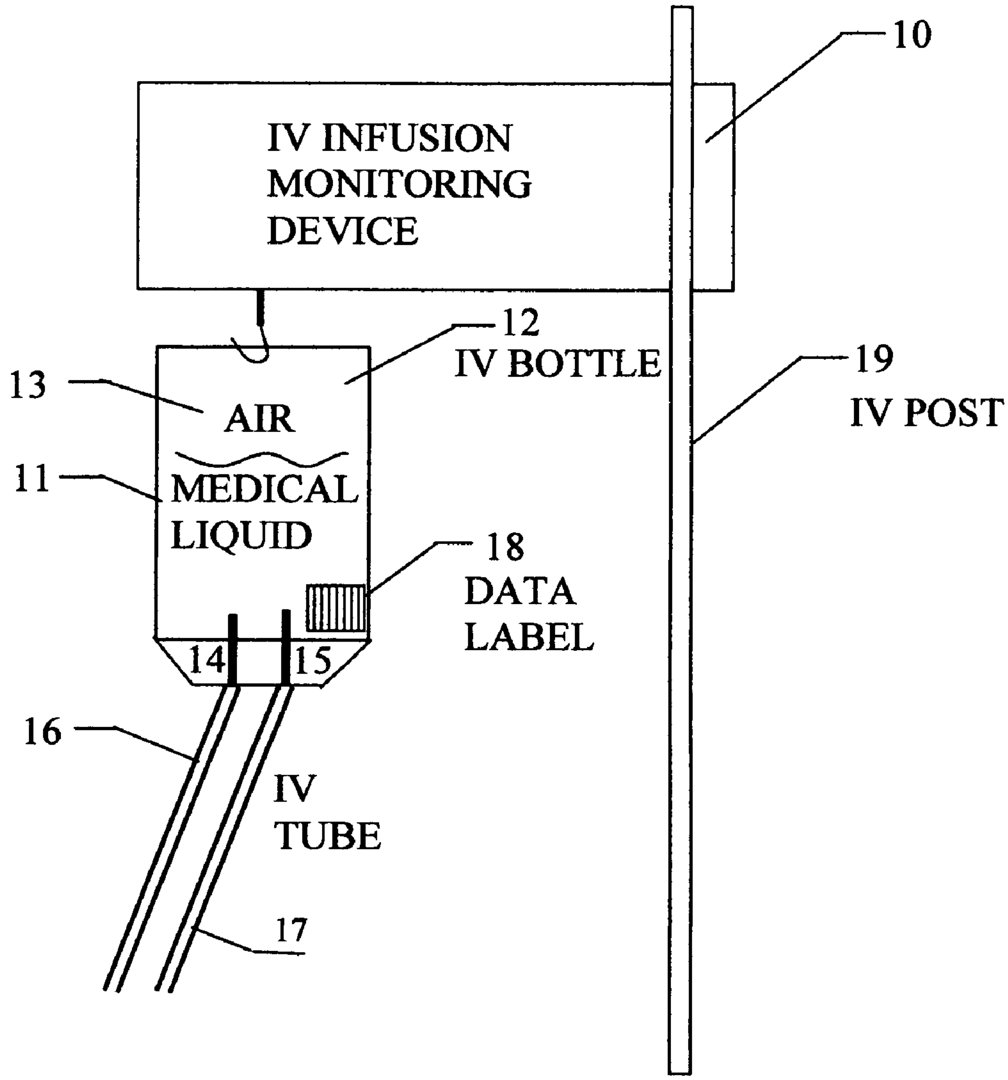
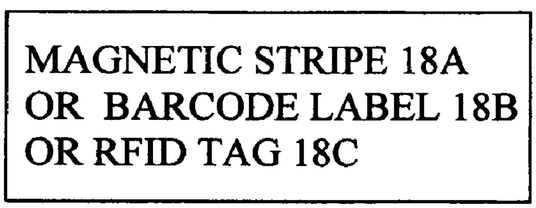
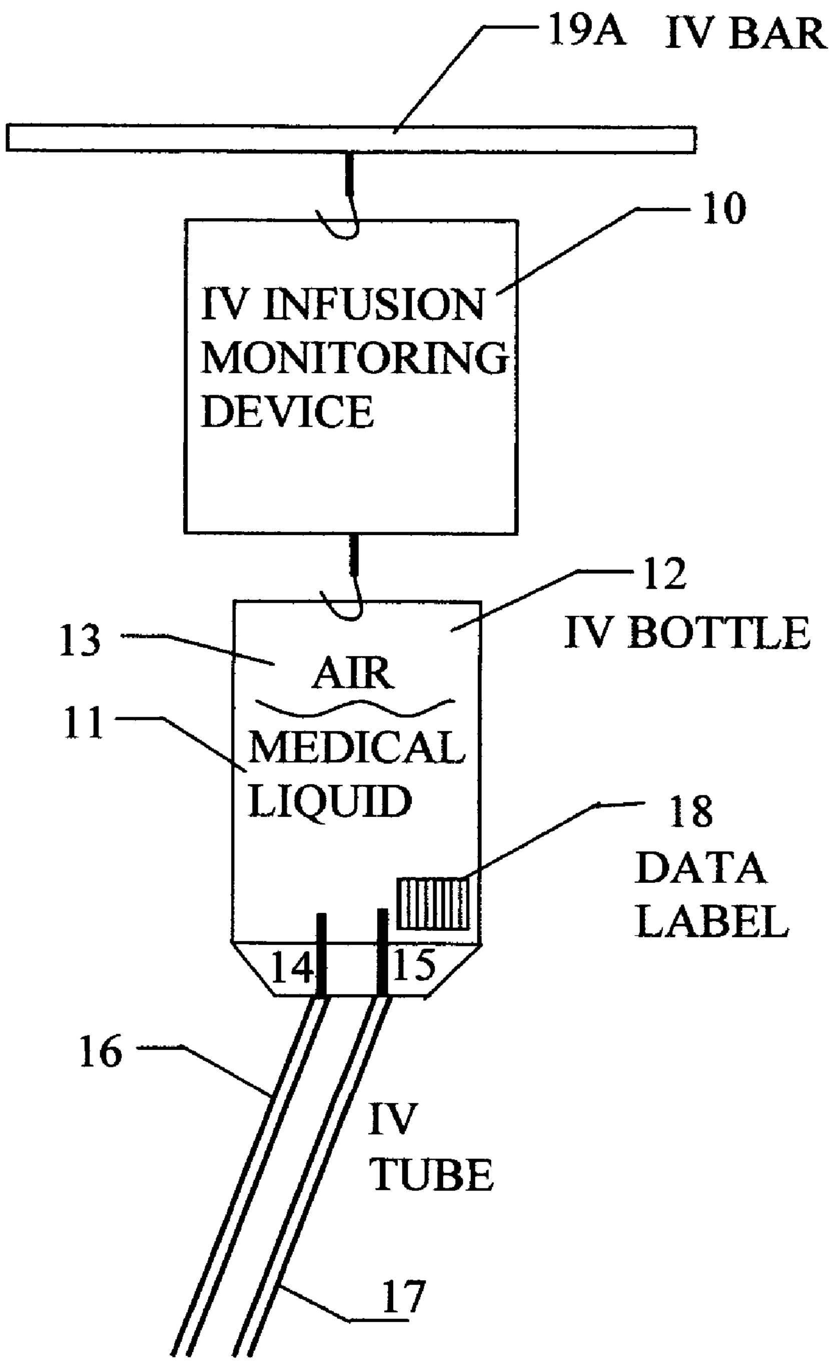


FIG. 1



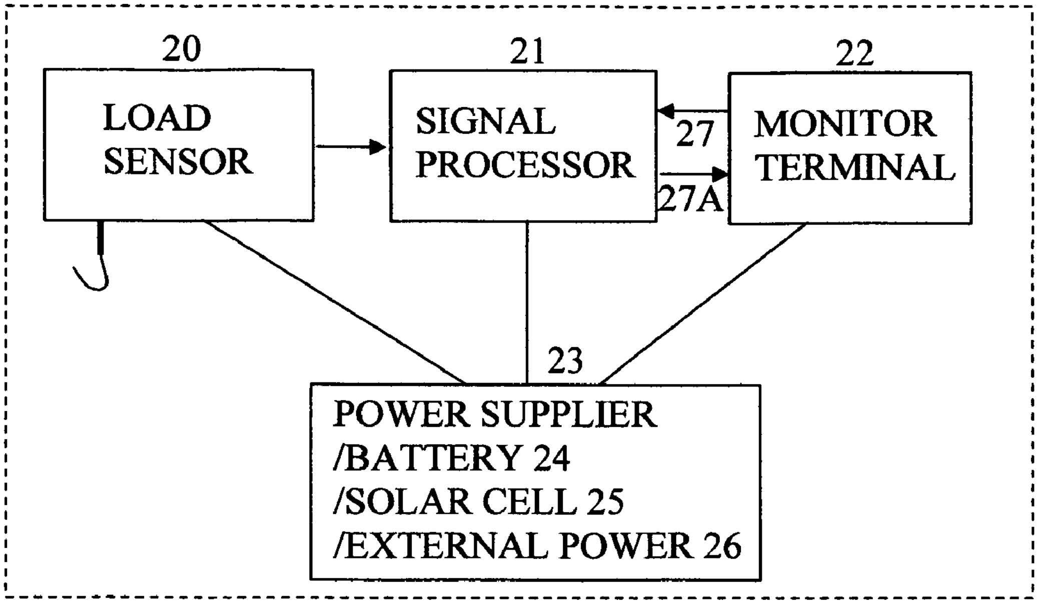
DATA LABEL 18

FIG. 1A



19A IV BAR
10
IV INFUSION
MONITORING
DEVICE
12
IV BOTTLE
13
AIR
11
MEDICAL
LIQUID
18
DATA
LABEL
14
15
16
IV
TUBE
17

FIG. 2



IV INFUSION MONITORING DEVICE 10

FIG. 3

ELECTRIC BRIDGE CIRCUIT 30

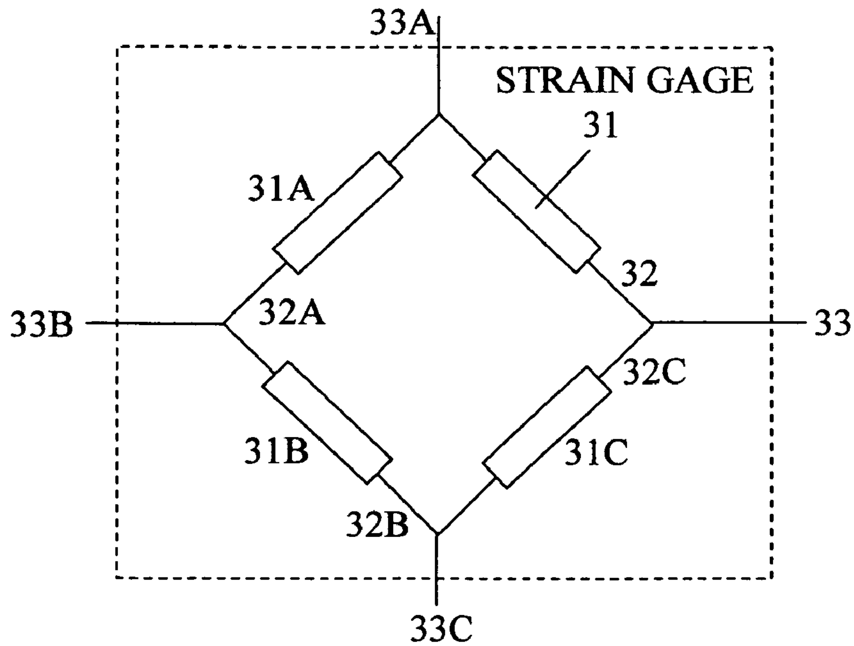
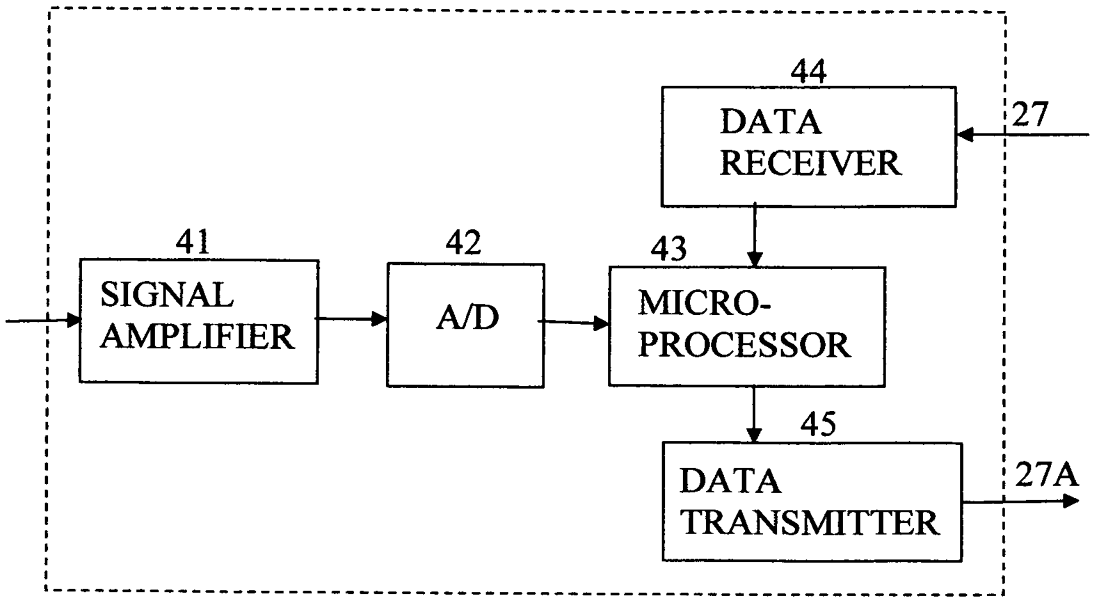
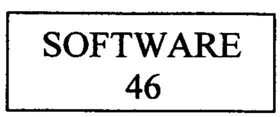


FIG. 4



SIGNAL PROCESSOR 21

FIG. 5



MICROPROCESSOR 43

FIG. 5A

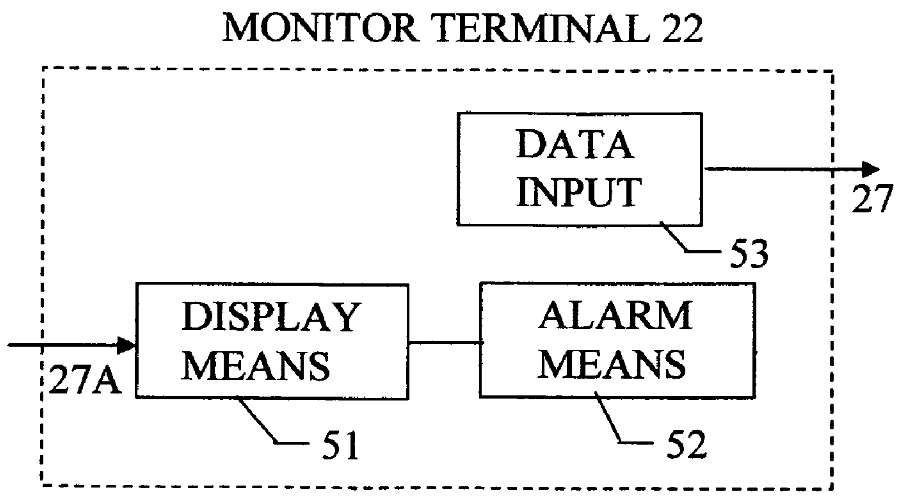


FIG. 6

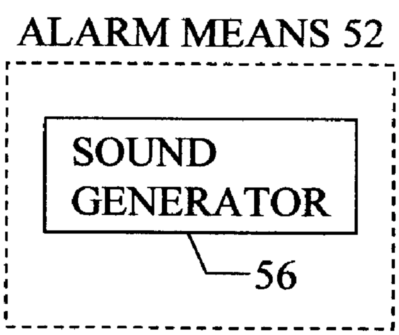


FIG. 6A

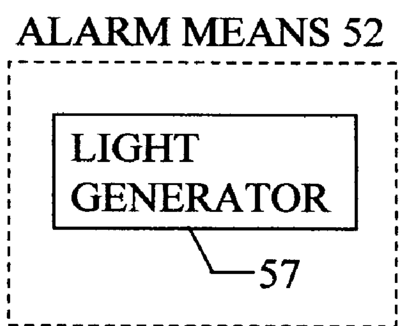


FIG. 6B

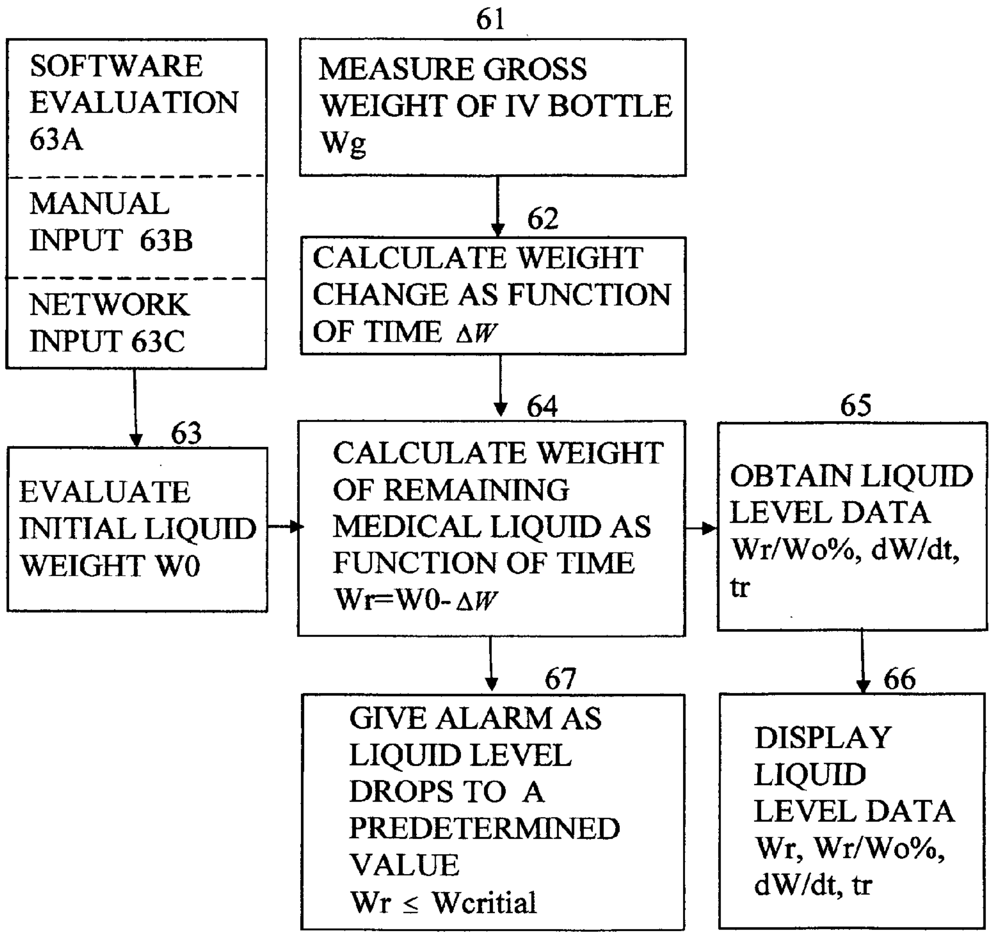

SOFTWARE EVALUATION 63A
MANUAL INPUT 63B
NETWORK INPUT 63C
61
MEASURE GROSS WEIGHT OF IV BOTTLE Wg
62
CALCULATE WEIGHT CHANGE AS FUNCTION OF TIME ΔW
63
EVALUATE INITIAL LIQUID WEIGHT W0
64
CALCULATE WEIGHT OF REMAINING MEDICAL LIQUID AS FUNCTION OF TIME Wr=W0-ΔW
65
OBTAIN LIQUID LEVEL DATA Wr/Wo%, dW/dt, tr
67
GIVE ALARM AS LIQUID LEVEL DROPS TO A PREDETERMINED VALUE Wr ≤ Wcritial
66
DISPLAY LIQUID LEVEL DATA Wr, Wr/Wo%, dW/dt, tr

FIG. 7

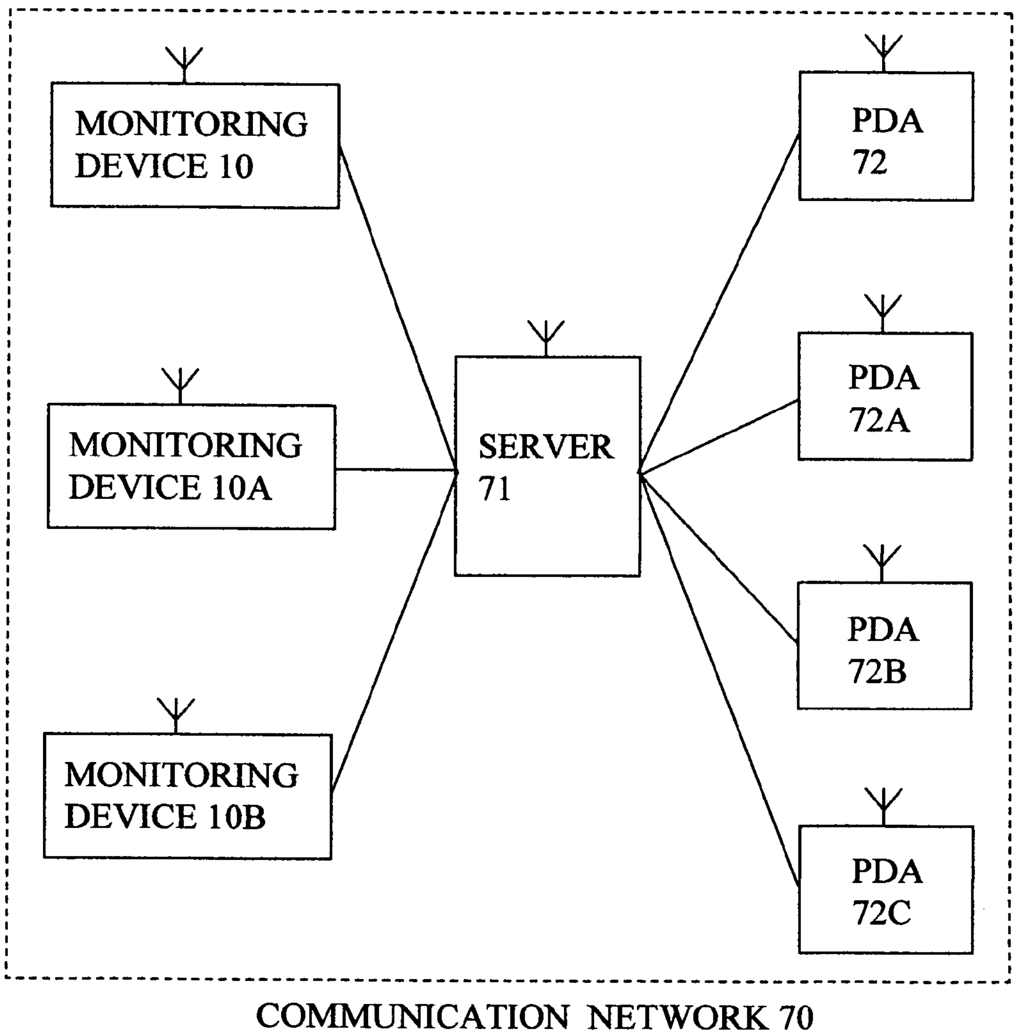

MONITORING DEVICE 10
MONITORING DEVICE 10A
MONITORING DEVICE 10B
SERVER 71
PDA 72
PDA 72A
PDA 72B
PDA 72C
COMMUNICATION NETWORK 70

FIG. 8

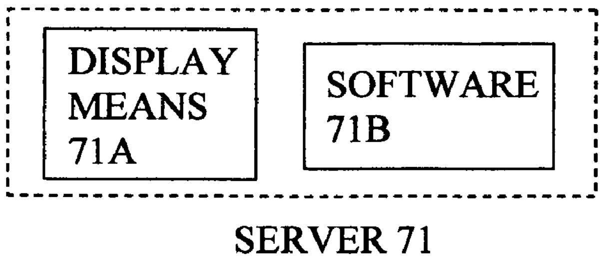

DISPLAY
MEANS
71A
SOFTWARE
71B
SERVER 71

FIG. 8A

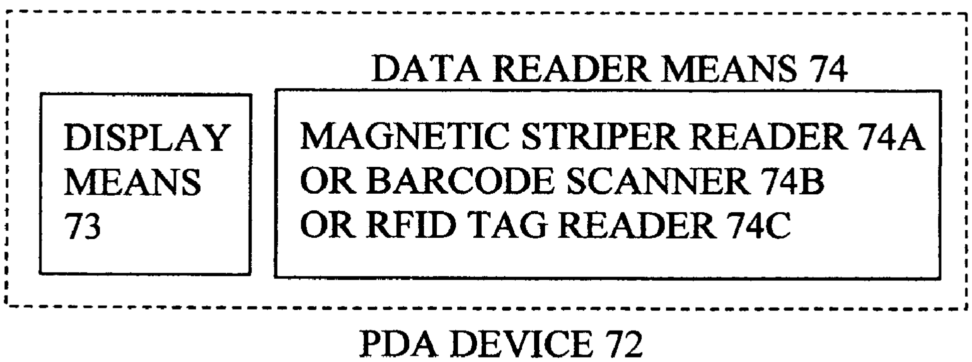

DATA READER MEANS 74
DISPLAY
MEANS
73
MAGNETIC STRIPER READER 74A
OR BARCODE SCANNER 74B
OR RFID TAG READER 74C
PDA DEVICE 72

FIG. 8B

IV INFUSION MONITORING DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of provisional patent application No. 61/338,636, filed on Feb. 22, 2010 by the present inventors to US Patent and Trademark Office.

REFERENCES CITED

U.S. Patent Documents

[0002]

3,656,478	Apr. 18, 1972	Swersey	604/66
3,939,360	Feb. 17, 1976	Jackson	307/118
4,589,372	May 20, 1986	Smith	119/51.02
5,563,584	Oct. 8, 1996	Rader et al.	340/618

FEDERALLY SPONSORED RESEARCH

[0003] Not applicable

SEQUENCE LIST OF PROGRAM

[0004] Not applicable

FIELD OF INVENTION

[0005] The present invention relates to a monitoring system of a liquid feeding line, and more particularly to an IV infusion monitoring device.

BACKGROUND OF THE INVENTION

[0006] Assume a patient lies on bed to receive IV infusion. There are two types of infusion systems. One is by pump, another is by gravity. The pump infusion system is very costly and often encounters maintenance trouble. Therefore, many hospital workers prefer to use the traditional gravity infusion system. The gravity IV infusion line consists of three parts: a) An IV bottle contains medical liquid and air above the medical liquid; (b) Infusion line includes a liquid needle inserted inside the IV bottle to receive medical liquid, a plastic tube (liquid tube) with one end connected to the liquid needle as liquid inlet and another end connected to the IV injection needle for injecting the medical liquid into the patient vein. A flow rate switch is located in the middle of the plastic tube to control the flow rate manually; (c) Air line includes an air needle inserted into the IV bottle to apply air pressure for driving the liquid flow, and a plastic tube (air tube) with one end connected to the air tube as air outlet and another end opened to the environment as air inlet. As the medical liquid in the IV bottle drops to a predetermined low level, i.e., nearly finished, the bottle must be replaced by a new one, otherwise air may enter the infusion line and causes serious medical problems.

[0007] So far, the job of bottle replacement needs frequent supervision from patient and nurses by eyeball. This task becomes a heavy burden of medical workers, particularly at night. To develop an alarming system for IV infusion becomes a big demand from hospitals and patients.

[0008] Furthermore, the hospitals also wish to monitor whole IV infusion process for better care of the patients. For example, an IV infusion process may go wrong if a patient or particularly a baby moves violently during infusion. In this case, monitoring whole infusion process, e.g., the liquid level and the infusion speed at each time moment, becomes necessary. Unfortunately, there is no any satisfied device existing in the current market for this task. The present invention provides an IV infusion monitoring device, which not only gives alarm when the IV bottle needs replacement, but also provides all IV infusion data during whole infusion process, e.g., the liquid level, the liquid flow rate and the remaining time from the completion of the infusion process. The present invention also includes a communication network, so that the nurses or other hospital workers can monitor the whole IV infusion process of each patient from either a close or a remote location through the network.

[0009] U.S. Pat. No. 3,656,478 to Swersey, discloses an infusion monitor which is able to supply a medical liquid to a patient at either a high rate or low rate, depending upon the weight of the patient. If the weight of the patient decreases below a preset value, the infusion monitor is switched to the high speed. If the weight of the patient returns to normal, the infusion monitor switches back to the low speed. The present invention is apparently different from the Swersey's. The present invention measures and monitors the weight of the medical liquid in the IV bottle, and calculates the liquid flow rate during infusion.

[0010] U.S. Pat. No. 3,939,360 to Jackson discloses a liquid level sensor and electrode assembly therefore. Jackson's disclosure applies three capacitance plates to measure the capacitance which is related to the liquid level. The present invention applies weight measurement of the medical liquid in the IV bottle by an electric load sensor to monitor the infusion process.

[0011] U.S. Pat. No. 4,589,372 to Smith discloses a dispensing system similar to the Swersey's. The Smith's system first determines the weight of an animal subject, and then a delivery unit supplies a predetermined amount of material to the animal subject. The amount of supplied material is a function of the weight of the subject. It is apparent that the present invention is completely different from the Smith's. The present invention monitors the weight of the remaining medical liquid in the IV bottle and the liquid flow rate during infusion, not the control of the infusion speed as a function of the weight of the animal subject.

[0012] U.S. Pat. No. 5,563,584 to Rader et al. discloses a liquid level sensing and monitoring system for medical fluid infusion systems. Rader's disclosure applies pressure sensor technology. A pressure sensor is inserted into the outlet of a liquid container and contacts the liquid for detecting the liquid level. The present invention applies the load sensor for measuring the weight of the medical liquid in the IV bottle during infusion.

[0013] The present invention provides an IV infusion monitoring device, which is capable for measuring and monitoring the liquid level and liquid flow rate of the medical liquid in the IV bottle during whole infusion process, as well as for giving alarm when the medical liquid in the IV bottle drops to a predetermined low level. The present invention is different from and superior over all the prior arts in function, structure, cost, accuracy and reliability, as well as ease of use.

SUMMARY OF THE INVENTION

[0014] An IV infusion monitoring device is provided to measure and to display the liquid level data including the weight of remaining medical liquid in an IV bottle, the liquid flow rate as number of drop per minute during infusion and the remaining time from the completion of the IV infusion process etc. It also gives alarm as the medical liquid in the IV bottle drops to a predetermined low level. The monitoring devices further combines with a server and at least one PDA devices (personal digital assistant) to form a communication network for IV infusion monitoring (i.e., network of things or interne of things for IV infusion monitoring). A PDA device is a mobile device, e.g., a remote desk top computer in a nurse station, a laptop computer, or a palmtop computer. The liquid level data are transmitted from the monitoring device to the server and then to the PDA devices through the communication network by wire or wirelessly. Therefore the nurses and other hospital workers can monitor the IV infusion process in a remote device, e.g. a desktop computer in a nurse station or a palmtop computer carried by a nurse or a hospital worker etc.

[0015] An IV infusion system is used for injecting a medical liquid to a patient vein. It includes an IV bottle containing medical liquid in bottom and air above the medical liquid. Both a liquid needle for liquid flow and an air needle for air flow are inserted into the IV bottle. A plastic liquid tube for liquid flow is connected at the end of the liquid needle. A plastic air tube for air flow is connected at the end of the air needle.

[0016] The preferred embodiment of the present invention comprises a load sensor, a signal processor, a monitor terminal and a power. The load sensor measures the gross weight of the IV bottle including the medical liquid and the attachments e.g., the needles and the tubes. The measured weight signal is then transmitted to the signal processor, which is able to process the measured weight signal and obtain the liquid level data including the weight of remaining medical liquid in an IV bottle, the liquid flow rate during infusion and the remaining time from the completion of the IV infusion process. The signal processor also compares the measured liquid level (e.g., the remaining weight of the medical liquid or the percentage of the remaining liquid weight over the initial liquid weight in the IV bottle) to a predetermined value, and sends out an alarm signal to the monitor terminal as the measured liquid level is equal or less than the predetermined value. Meanwhile, all the liquid level data are sent from the signal processor to the monitor terminal for display during infusion process. The power is provided preferably by a battery or a solar cell, alternatively by an external power source as an option to user.

[0017] The load sensor includes at least one strain gage. As a mechanical load (i.e., the gross weight of the IV bottle) is applied, the load is sensed by the strain gage, which outputs an electric signal, e.g., a voltage, in proportional to the applied mechanical load. The strain gage can be bonded or un-bonded, can be made of metal or semiconductor, can be made of resistor or capacitor or inductor. To compensate the temperature change and obtain the best resolution, typically, at least one strain gages and other electric parts (e.g., resistor, capacitor and inductor) form an electric bridge circuit consisting of 4 arms and 2 pair of ends, in which two ends receive an applied voltage while another two ends output the electric signal in proportional to the applied load on the at least one strain gage.

[0018] The signal processor comprises (a) a signal amplifier, which is able to amplify the measured weight signal (e.g., a voltage) received from the load sensor, (b) an A/D converter, which converts the amplified weight signal (e.g. an analog voltage) into a plurality of digital data, (c) a microprocessor, which has software to analyze the plurality of digital data statistically and obtain the liquid level data. There is much interference electrically or mechanically during infusion process, for example, as the patient moves or IV bottle is touched, the measured signal values vary. The microprocessor receives a plurality of digital data during infusion process including interference and noise. The software in the microprocessor is able to statistically analyze these data and filter out the interference and noises in order to obtain accurate weight measurement of the medical liquid as a function of time. The liquid flow rate of the medical liquid in the IV bottle is calculated as weight change per unit time, it can be converted into number of drop per unit time by using the estimated weight of each drop. The software is also capable for evaluating the initial weight of the medical liquid in the IV bottle. In addition, the software compares the measured weight of remaining medical liquid in the IV bottle with the predetermined value, and sends out an alarm signal as the measured weight is equal or less than the predetermined value.

[0019] The monitor terminal comprises (a) a display mean which is able to display all liquid level data including the weight of remaining medical liquid in the IV bottle, liquid flow rate and the time from the completion of the IV process, (b) an alarm means which gives alarm as the monitor terminal receives an alarm signal from the signal processor, and (c) a data input means which receives data input and sends them to the signal processor. The data input means includes manual input or the input from the communication network. The display means includes a liquid-crystal screen on the monitor terminal. The alarm means includes a sound generator or a light generator.

[0020] There are two different monitoring modes, one is single monitoring mode, and another is network monitoring mode. In single monitoring mode, the monitoring is carried out in each monitoring device. In network monitoring mode, each set of liquid level data are transmitted through the communication network by wire or wirelessly from each monitoring device to a remote device, e.g., a desktop computer in a nurse station, a server or a palmtop computer carried by a nurse or a hospital worker in a remote location.

[0021] The alternative embodiment is a method to monitor the IV infusion process. The load sensor measures the gross weight Wg of the IV bottle including the medical liquid and the attachments, e.g., the needles and the tubes as a function of time. The measured weight signal is transmitted to a signal amplifier for amplification. An A/D converter receives the amplified signal from the signal amplifier and converts the analog signal to a plurality of digital data, which are then passed to a microprocessor for data analysis statistically to filter out all interference and noise etc. The microprocessor then calculates the weight change ΔW as a function of time during infusion. Since all parts have fixed weight except the medical liquid during infusion, the weight change must be the weight decrease of the medical liquid during infusion. The initial weight Wo of the medical liquid is evaluated at the beginning of the infusion process by one of 3 different methods: (a) Evaluated by the software in microprocessor based the standard weight category of the medical liquid in the IV bottle; (b) Manual input from monitor terminal, this is not preferred option since it increases the nurse's working load; (c) Input from the communication network. All the IV data from a doctor is inputted into the computer system including the patient name, IV identification, the name and quantity of the medicine and solution etc. These IV data are stored in the computer system, and will be transmitted into the microprocessor through the communication network. The weight of remaining medical liquid in the IV bottle is calculated based on the difference between the initial weight of the medical liquid in the IV bottle and the weight change during infusion: $Wr=Wo-\Delta W$. The percentage of the remaining medical liquid weight and the liquid flow rate are then respectively: Wr/Wo % and dW/dt. The remaining time from completion of the infusion process is obtained by dividing Wr by dW/dt. These liquid level data are sent to the monitor terminal for display in single monitoring mode, and are sent to the communication network in network monitoring mode so that a nurse or a hospital worker can monitor the infusion process from a remote location. The microprocessor also compares the weight of the remaining medical liquid to a predetermined value Wcritical, and sends an alarm signal to the monitor terminal to generate an alarm if the weight of the remaining medical liquid is equal or less than the predetermined value: Wr. Meanwhile if the liquid flow rate is too low in comparison to a predetermined rate vale due to some accident during the infusion process, an alarm will also be generated to alert the nurses.

BRIEF DESCRIPTION OF THE DRΔWINGS

[0022] FIG. **1** is a schematic drawing of the installation of an IV infusion monitoring device for the present invention.

[0023] FIG. **1**A is a block diagram of an exemplary data label for the present invention.

[0024] FIG. **2** is the schematic drawing of an alternative installation method of an IV infusion monitoring device for the present invention.

[0025] FIG. **3** is a block diagram of an exemplary IV infusion monitoring device for the present invention.

[0026] FIG. **4** is the schematic drawing of an exemplary electric bridge circuit of the load sensor in the present invention.

[0027] FIG. **5** is a block diagram of an exemplary signal processor for the present invention.

[0028] FIG. **5**A is a block diagram of an exemplary microprocessor including software for the present invention.

[0029] FIG. **6** is a block diagram of an exemplary monitor terminal for the present invention.

[0030] FIG. **6**A is a block diagram of an exemplary alarm means of the monitor terminal in the present invention.

[0031] FIG. **6**B is a block diagram of an alternative alarm means of the monitor terminal in the present invention.

[0032] FIG. **7** is a flow chart of a monitoring method for the present invention.

[0033] FIG. **8** is a block diagram of a communication network by using the monitoring device.

[0034] FIG. **8**A is a block diagram of an exemplary server in the present invention.

[0035] FIG. **8**B is a block diagram of an exemplary PDA device in the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

[0036] In describing preferred embodiment of the present invention illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the invention is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents which operate in a similar manner to accomplish a similar purpose.

[0037] FIG. **1** is a schematic drawing of the installation of an IV infusion monitoring device **10** for the present invention that is capable of detecting the liquid level data including the weight of the remaining medical liquid **11** in an IV bottle **12** or the ratio of the weight of the remaining medical liquid **11** over the initial weigh of the medical liquid **11**, liquid flow rate, and the remaining time from completion of IV process. It gives alarm when the weight of the remaining medical liquid **11** in the IV bottle **12** drops to a predetermined low level. It also gives alarm if the IV infusion process encounters some trouble and results in a very slow liquid flow rate below a predetermined rate value.

[0038] An IV infusion system comprises the IV bottle **12**, a liquid needle **14**, an air needle **15**, a liquid tube **16** and an air tube **17**. The IV bottle **12** contains the medical liquid **11** in its bottom and the air **13** above the medical liquid **11**. The IV bottle **12** functions as a liquid supply source during infusion. The IV bottle **12** can be made of stiff materials such as glass or harden plastics, or it can be made of flexible plastic bags. The liquid needle **14** and an air needle **15** are inserted into the IV bottle **12**. The liquid tube **16** is connected at the end of the liquid needle **14**. The air tube **17** is connected at the end of the air needle **15**. A data label **18** (FIG. **1**A) including either of a magnetic stripe **18**A, barcode label **18**B or RFID tag **18**C is disposed outside the IV bottle **12** for containing all IV data including patient name, IV identification, the name and quantity of medicine and solution etc. The weight of the medical liquid **11** can be converted from weight unit (g) to volume unit (ml). The liquid flow rate can be converted from weight per unit time into the number of liquid drop per unit time based on estimated weight per drop.

[0039] Preferably, the IV infusion monitoring device is installed in an IV post **19**, which is fixed in a patient bed or seat, or stands alone next the patient bed or seat.

[0040] FIG. **2** is the schematic drawing of an alternative installation method of the present invention. The IV infusion monitoring device **10** is installed in an IV bar **19**A, which is fixed above the patient bed or seat horizontally. Alternatively, the IV infusion monitoring device **10** can be installed or held in any other position near the patient as long as the IV bottle **12** is relatively stable during infusion as well as it is above the patient to provide enough gravitational driving force for the medical liquid flow.

[0041] FIG. **3** is a block diagram of an exemplary IV infusion monitoring device for the present invention. The IV infusion monitoring device **10** comprises a load sensor **20**, a signal processor **21**, a monitor terminal **22** and a power **23**. The load sensor **20** measures the gross weight of the IV bottle **12** including the medical liquid **11** and its attachments e.g., the needles **14**, **15** and the tubes **16**, **17**. The measured weight signal is then transmitted to the signal processor **21**, which is able to process the signal and obtain the liquid level data including the weight of the remaining medical liquid **11** in the IV bottle **12** or the ratio of the weight of the remaining medical liquid **11** over the initial weigh of the medical liquid **11**, liquid flow rate, and the remaining time from completion of IV process. The signal processor **21** also compares the measured weight of remaining medical liquid **11** to a predetermined value, and sends out an alarm signal to the monitor terminal **22** as the measured weight of remaining medical liquid **11** is equal or less than the predetermined value. All the liquid level data are sent from the signal processor **21** to the monitor terminal **22** by wire **27**A for display during infusion process. The monitor terminal **22** gives an alarm in response to the alarm signal from the signal processor **21**. In addition, the monitor terminal **22** is capable of transmitting an input data to the signal processor **21** by wire **27**. The power **23** is provided preferably by a battery **24** or a solar cell **25**, alternatively by an external power source **26** as an option to user. If the power is provided by a battery **24** or a solar cell **25**, the negative pole of the battery **24** or solar cell **25** will act as a reference zero potential point, and therefore, all parts are non-grounded and the monitoring device **10** becomes portable, i.e., it can move around with a patient while in working condition.

[0042] FIG. **4** is the schematic drawing of an exemplary electric bridge circuit **30** of the load sensor **20** in present invention. The load sensor **20** includes at least one strain gage **31**. As a load (i.e., the gross weight of the IV bottle) is applied, the load is sensed by the strain gage **31**, which outputs an electric signal (i.e., measured weight signal), e.g., a voltage in proportional to the applied load. The strain gage **31** can be bonded or un-bonded, can be made of metal or semiconductor, and can be made of resistor or capacitor or inductor. To compensate the temperature change and obtain the best resolution, typically, at least one strain gages (e.g, one gage, two gages or four gages) and other electric parts (resistor, capacitor and inductor) **31**, **31**A, **31**B and **31**C form an electric bridge circuit **30** consisting of 4 arms **32**, **32**A, **32**B, **32**C and 2 pair of ends **33**, **33**A, **33**B, **33**C, in which two ends **33**, **33**B receive an applied voltage while another two ends **33**A, **33**C output the electric signal in proportional to the applied load on its at least one strain gage **31**.

[0043] FIG. **5** is a block diagram of an exemplary signal processor **21** for the present invention. The signal processor **21** comprises a signal amplifier **41**, an A/D converter **42**, a microprocessor **43**, a data receiver **44** and a data transmitter **45**. The signal amplifier **41** is able to amplify the measured weight signal (e.g., a voltage) received from the load sensor **20**. The A/D converter **42** converts the amplified weight signal (e.g. an analog voltage) into a group of digital data. The microprocessor **43** contains software **46** (FIG. **5**A) to analyze the digital data statistically and to obtain the liquid level data. The data receiver **44** receives input data from monitor terminal **22** by wire **27**. The data transmitter **45** sends out liquid level data to monitor terminal **22** by wire **27**A. There is much interference electrically or mechanically during infusion process, for example, as the patient moves or IV bottle **12** is touched, the measured weight signal values vary. The microprocessor **43** receives a plurality of data during infusion process; these data also include interference and noises. The software **46** in the microprocessor **43** is able to statistically analyze these data to filter out the interference and noises in order to obtain accurate weight measurement of the medical liquid **11** in the IV bottle **12** as a function of time. The software **46** is also capable for evaluating the initial weigh of the medical liquid **11** in the IV bottle **12**. The initial weight of the medical liquid **11** can also be obtained alternatively from manual input in the monitor terminal **22** or from a communication network **70** (FIG. **8**). The liquid weight can be converted from weight unit (g) to volume unit (ml) by using the liquid specific weight. The liquid flow rate is calculated as weight change per unit time. However, the unit of the flow rate can be converted from weight per unit time to number of drops per unit time by using estimated weight per drop. The remaining time from the completion of IV process is obtained based on the remaining liquid weight and the liquid flow rate. In addition, the software **46** compares the measured weight of the medical liquid **11** or the liquid flow rate to the predetermined values, and sends out an alarm signal as the measured weight of the medical liquid **11** or liquid flow rate are equal or less than the predetermined weight value or rate value respectively.

[0044] FIG. **6** is a block diagram of an exemplary monitor terminal **22** for the present invention. The monitor terminal **22** comprises a display mean **51**, an alarm means **52** and a data input means **53**. The display means **51** is able to display the liquid level data. The alarm means **52** gives alarm as the monitor terminal **22** receives an alarm signal from the signal processor **21**. The data input means **53** receives data input manually or from the communication network **70** (FIG. **8**), and sends them to the signal processor **21**. The monitor terminal **22** communicates with the signal processor **21** by wire **27**, **27**A. The display means **51** includes a liquid-crystal screen on the monitor terminal **22**. The alarm means **52** includes either a sound generator **56** (FIG. **6**A) or a light generator **57** (FIG. **6**B).

[0045] FIG. **7** is a flow chart of a monitoring method for the present invention. Step **1** (**61**): The load sensor **20** measures the gross weight of the IV bottle **12** including the medical liquid **11** and the attachments, i.e., the needles **14**, **15** and the tubes **16**, **17**, and obtains a measured weight signal. The measured weight signal is amplified by the signal amplifier **41** to obtain an amplified weight signal. The amplified weight signal is further converted from an analog signal into a group of digital data, which are then analyzed statistically by the microprocessor **43** to obtain the gross weight Wg of the IV bottle **12** including the medical liquid **11** and the attachments **14**, **15**, **16**, **17** as a function of time. Step **2** (**62**): The microprocessor **43** statistically analyzes the group of digital data Wg to filter out interference and noise, and calculates the weight change ΔW of the IV bottle **12** including the medical liquid **11** and the attachments **14**,**15**,**16**,**17** as a function of time during infusion. Since all parts of the IV infusion system have fixed weight except the medical liquid **11** during infusion, the calculated weight change must be the weight decrease ΔW of the medical liquid **11** during the infusion. Step **3** (**63**): The initial weight Wo of the medical liquid **11** is evaluated at the beginning of the infusion process by one of 3 different methods: (a) (**63**A) Evaluated by the software **46** in the microprocessor **43**. The initial weight of the medical liquid **11** is not arbitrary, it is manufactured in standardized categories (e.g., 50 g, 100 g, 250 g, and 500 g etc., which can be converted into volume unit ml by liquid specific weight), and the weight of other parts are much smaller than the medical liquid **11**. Therefore, it is not difficult for software **46** to determine which initial weight category the medical liquid **11** belongs to. For example, if the initial gross weight of the IV bottle **12** is measured to be between 260 g and 400 g, the initial weight of the medical liquid **11** must be 250 g (or 250 ml in volume) after deducting the weight of IV bottle **12**, needles **14**, **15** and tubes **16**, **17**, it is the same for other weight categories of 50 g, 100 g, 500 g, 1000 g etc.; (b) (**63**B) Manual input from monitor terminal **22**, this is not a preferred option since it increases the nurse's working load; (c) (**63**C) Input through communication network **70** from a remote device, e.g., a server **71** (FIG. **8**A) or a PDA device **72** (FIG. **8**B). All the medical prescription data from a doctor is inputted into the computer system including IV data, e.g., the patient name, IV identification, the name and quantity of the medicine and solution etc. These IV data are stored in the computer system, and will be transmitted into the microprocessor **43** through communication network **70**, for example, the PDA device **72** including a data reader means **74** (one of a magnetic stripe reader **74**A, a barcode scanner **74**B or a RFID tag reader **74**C) to read in the IV data from the data label **18** and then transmit all the IV data to the server **71** and then to the microprocessor **43**. Step **4** (**64**): The weight of remaining medical liquid **11** Wr in the IV bottle **12** at a given time is calculated by the difference between the initial weight of the medical liquid **11** Wo and the weight change ΔW at the given time during infusion: Wr=W0−ΔW. Step **5** (**65**): The percentage of the remaining medical liquid weight and the liquid flow rate (weight change per unit time) are then obtained respectively: Wr/Wo % and dW/dt. Hereby, the liquid level is defined as either Wr or Wr/Wo %. The remaining time from the completion of the IV infusion process tr can also be calculated, e.g., dividing the remaining liquid weight Wr by the liquid flow rate dW/dt. The liquid level data including the liquid level Wr or Wr/W0%, liquid flow rate dW/dt and the remaining time from IV completion tr. The unit of the weight can be converted between g and ml by liquid specific weight, and the unit of liquid flow rate can be converted between g/s and drop/s by liquid weight per drop. Step **6** (**66**): These liquid level data are sent to the monitor terminal **22** for display, or are sent to the communication network **70** for display in a remove device, e.g., a server **71** (FIG. **8**A) or a PDA device **72** (FIG. **8**B). Step **7** (**67**): The microprocessor **43** also compares the weight of the remaining medical liquid **11** to a predetermined value Wcritical (e.g., 10 g), and sends out an alarm signal to the monitor terminal **22** or the communication network **70** to generate alarm if the weight of the remaining medical liquid **11** is equal or less than the predetermined value: Wr≦Wcritical. Meanwhile, if any trouble occurs during the IV infusion process, the liquid flow rate may become very low, then an alarm will also be generated to alert the nurses for treatment as the liquid flow rate drops below a predetermined rate value. The above sequence of steps is applied for sake of convenience. Any change of the sequence also gives technical equivalent of the monitoring method, for example, the step **3** could move to before step **1**, and it still gives the same method.

[0046] FIG. **8** is a block diagram of a communication network **70**. There are two different monitoring modes, one is single monitoring mode, and another is network monitoring mode. In single monitoring mode, the monitoring device **10** alone is applied for each patient, and the IV infusion process is monitored by using the monitoring device **10** only. In network mode, a communication network for IV infusion monitoring **70** (i.e., internet of things or network of things for IV infusion monitoring) comprises at least one monitoring device **10**, **10**A, **10**B, a server **71** and at least one PDA device (personal digital assistant) **72**, **72**A, **72**B, **72**C. Each monitoring device **10**, **10**A, **10**B is located next to each patient under IV infusion process for measuring the liquid level data including the liquid level Wr or Wr/Wo %, the liquid flow rate dW/dt and the remaining time tr from the completion of IV process. The server **71**, as shown in FIG. **8**A, typically a PC, includes display means **71**A for displaying received liquid level data, as well as software **71**B to analyze and to manage data flow within the communication network **70**. Each PDA device (i.e., personal digital assistant) **72**, **72**A, **72**B, **72**C, e.g., a remote desk top computer in a nurse station, a laptop computer, a palmtop computer or other mobile devices, as shown in FIG. **8**B, is carried by a nurse or a hospital worker. Each PDA includes display means **73** for displaying received liquid level data and a data reader means **74**, e.g., a magnetic stripe reader **74**A, a barcode scanner **74**B or a RFID tag reader **74**C for scanning and reading in the IV data contained in the data label **18** attached outside the IV bottle **12**. The liquid level data are transmitted from at least one monitoring device **10**, **10**A, **10**B to the server **71** by wire or wireless. The server **71** further sends all the liquid level data to each PDA device **72**, **72**A, **72**B, **72**C by wire or wireless. In reverse turn, the IV data including patient name, IV identification, the name and quantity of medicine and solution etc. are read by the PDA device **72**, **72**A, **72**B, **72**C and they are then transmitted back to server **71** and further to each monitoring device **10**, **10**A, **10**B. The server **71** is also capable to directly receive input data from the users.

What is claims is:

1. An IV infusion monitoring device, comprising:

(a) a load sensor including at least one strain gage for measuring weight of medical liquid in an IV bottle and for sending a measured weight signal to a signal processor,

(b) said signal processor having

signal amplifier for amplifying said measured weight signal and outputting an amplified weight signal,

A/D converter for converting said amplified weight signal from analog signal to a group of digital data,

microprocessor having software for statistically analyzing said a group of digital data and obtaining liquid level data, said liquid level data including weight of remaining medical liquid in said IV bottle, liquid flow rate, and remaining time from completion of IV process,

data transmitter for transmitting said liquid level data to a monitor terminal,

(c) said monitor terminal having

display means for displaying said liquid level data,

alarm means for give alarm as said weight of remaining medical liquid drops to a predetermined value,

(d) power supplier comprising selected one of battery, solar cell and external power source for providing power to said monitoring device.

2. The monitoring device of claim **1**, wherein said load sensor including an electric bridge circuit consisting of 4 arms and 2 pair of ends, said at least one strain gage being installed in at least one arm, two ends of said electric bridge receiving applied electric voltage while other 2 ends of said electric bridge outputting measured signal in proportional to applied weight load on said at least one strain gage, said at least one strain gage being made of at least one of resistor, capacitor and inductor.

3. The monitoring device of claim **1**, wherein said monitor terminal including said alarm means for give alarm as said liquid flow rate drops to a predetermined rate value,

4. The monitoring device of claims, wherein selected one of magnetic stripe, barcode label and RFID tag being disposed outside said IV bottle for providing IV data.

5. The monitoring device of claim **1**, wherein said monitoring device connecting to a server and said server connecting to at least one PDA devices by selected one of wire and wireless for forming a communication network, said server including software for analyzing and managing data flow within said communication network and display means for displaying said liquid level data, said at least one PDA devices including display means for displaying said liquid level data and data reader means including selected one of magnetic stripe reader, barcode scanner and RFID tag reader for reading said IV data, said liquid level data being transmitted from said monitoring device to said server, and being further transmitted to said at least one PDA devices, said IV data being transmitted back from said at least one PDA devices to said server and further to said monitoring device.

6. A method of monitoring IV infusion comprising:

(a) evaluating initial weight Wo of medical liquid in an IV bottle by a microprocessor,

(b) measuring gross weight of said IV bottle including said medical liquid and attachments by a load sensor, and obtaining a measured weight signal,

amplifying said measured weight signal by a signal amplifier, and obtaining an amplified weight signal,

converting said amplified weight signal from an analog signal to a group of digital data,

analyzing statistically said a group of digital data and obtaining said gross weight Wg as a function of time,

(c) calculating weight change ΔW of said IV bottle including said medical liquid and said attachments as a function of time by said microprocessor,

(d) calculating weight of remaining medical liquid Wr=Wo−ΔW in said IV bottle as a function of time by said microprocessor,

$$\frac{Wr}{Wo}\ \%,$$

(e) calculating percentage of said weight of remaining medical liquid

(f) calculating liquid flow rate

$$\frac{dW}{dt}$$

as weight per unit time,

(g) calculating remaining time from completion of IV process tr,

(h) displaying liquid level data, said liquid level data including said weight of remaining medical liquid, said liquid flow rate, and said remaining time from completion of IV process,

(g) giving alarm as said weight of remaining medical liquid drops to a predetermined value.

7. The method of claim **6**, wherein said liquid level data being transmitted to a server from a monitoring device by selected one of wire and wireless through a communication network, said liquid level data being further transmitted to a PDA device from said server by selected one of wire and wireless through said communication network.

8. The method of claim **6**, wherein selected one of magnetic stripe, barcode label and RFID tag being disposed outside said IV bottle for containing IV data, said IV data including at least one of patient name, IV identification, name and quantity of medicine, as well as name and quantity of solution, said IV data being read by selected one of magnetic stripe reader, barcode scanner and RFID tag reader in said PDA device, being transmitted from said PDA device to said sever, and being further transmitted to said monitoring device by selected one of wire and wireless through said communication network.

9. The method of claim **6**, wherein said initial weight Wo being inputted manually in a monitor terminal.

10. The method of claim **6**, wherein said initial weight Wo being inputted through said communication network from said server.

11. The method of claim **6**, wherein said initial weight Wo being inputted through said communication network from said PDA device by selected one of magnetic stripe reader, barcode scanner and RFID tag reader.

12. The method of claim **6**, wherein said weight of medical liquid in said IV bottle being converted from unit of weight to unit of volume.

13. The method of claim **6**, wherein said liquid flow rate being converted into number of liquid drop per unit time based on estimated weight per drop.

14. The method of claim **6**, wherein said alarm being given as said liquid flow rate drops to a predetermined rate value.

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