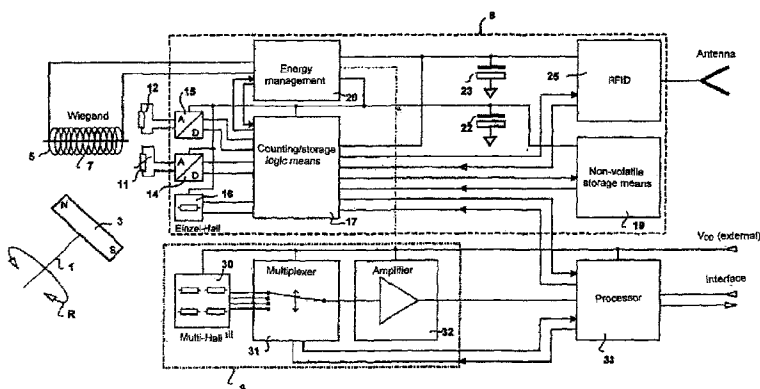




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(54) Titre : PROCEDE ET DISPOSITIF DE DETERMINATION DE LA MASSE D'UN FLUIDE S'ECOULANT PENDANT UN
INTERVALLE DE TEMPS DE CONSOMMATION A TRAVERS UN DEBITMETRE
(54) Title: METHOD AND APPARATUS FOR DETERMINING THE MASS OF A FLUID FLOWING THROUGH A FLOW
RATE METER IN A CONSUMPTION TIME INTERVAL



(57) **Abrégé/Abstract:**

The mass of a fluid flowing through a flow rate meter at a temperature which fluctuates within a given temperature range is determined by driving an exciter magnet system through the fluid at an exact correlation between the fluid volume flow and the movement path through which the exciter magnet system travels, generating, with the aid of a Wiegand wire and a coil surrounding said Wiegand wire, a measurement voltage pulse each time the exciter magnet system has traveled through a movement path corresponding to a unit volume of the fluid, charging, at each measurement time, a first energy store using electrical energy contained in each measurement voltage pulse and using said energy as operating energy for measuring the instantaneous temperature of the fluid, generating a temperature value as an integral multiple of the smallest resolvable temperature unit of measurement and an integral measured value comprising said temperature value and adding said temperature value to a sum of the previously determined measured values, said sum being contained in a nonvolatile memory, so as to form a continuous sum in the nonvolatile memory, and forwarding said continuous sum to a processor which can be supplied with external energy and which calculates the temperature-corrected delivery volume of the fluid from said continuous sum.



Abstract

The mass of a fluid flowing through a flow rate meter at a temperature which fluctuates in a given temperature range is determined by driving an exciter magnet system through the fluid with an exact correlation between the fluid volume flowing there through and the movement path covered by the exciter magnet system, producing a measurement voltage pulse after each passage through a movement path corresponding to a unit volume of the fluid by means of a Wiegand wire and a coil surrounding same, at each measurement time charging a first energy storage means by electric energy contained in each measurement voltage pulse, and using same as operating energy for measurement of the instantaneous temperature of the fluid, producing a temperature value as an integral multiple of the smallest temperature measurement unit to be resolved and an integral count value including said temperature value, and adding same to a sum contained in a non-volatile storage means from the precedingly ascertained count values for forming an ongoing sum in the non-volatile storage means and passing same to a processor which can be supplied with external energy and which calculates therefrom the temperature-corrected delivery volume of the fluid.

Method and apparatus for determining the mass of a fluid flowing through a
flow rate meter in a consumption time interval

5 The invention concerns a method of determining the mass of a fluid flowing through a flow rate meter, in particular gas, as set forth in the classifying portion of claim 1, and an apparatus suitable for carrying out that method.

10 Flow rate meters are known, which serve to detect the amount of a gas or a liquid, or generally a fluid, which flows through same from a supplier to a consumer and to form a counter status which is read off at certain time intervals to ascertain the mass of the fluid which has flowed through the flow rate meter in the time interval preceding the reading-off operation, as that mass is uniquely correlated with the energy which is
15 delivered to the consumer and which is stored in the fluid, on the assumption that the chemical and/or physical composition of the fluid does not change.

 In the description hereinafter for the sake of simplicity reference is primarily made to gas meters or gas flow rate meters, but it should be
20 expressly noted that the method according to the invention can also be used in the same manner for liquid flow rate meters.

 Many of the gas flow rate meters which are usual at the present time are in the form of bellows-type meters, that is to say measurement chambers which are separated from each other by diaphragms are
25 periodically filled and emptied. A joint linkage mechanism transmits the diaphragm movement to a crankshaft which drives two sliders which control the gas flow. Thus the gas flow is passed alternately through a bellows. The rotary movement of the linkage mechanism is transmitted by way of a magnetic coupling to a mechanical counting mechanism which generally
30 cannot be reset to prevent attempted manipulation. The measurement chambers predetermine a unit volume V_E and the counter status of the counting mechanism is increased by one each time when a unit volume V_E has been delivered to the consumer.

The counter status is read off at selectable time intervals, for example yearly, and the amounts of fluid supplied to the consumer in question are billed as a multiple of the unit volume V_E , for example in liters or cubic meters. It is assumed in that respect that the pressure of the fluid flowing
 5 through the flow rate meter is constant at all times, that is to say it is of a fixedly predetermined value.

If then the fluid is also at a constant temperature which for example is equal to the usually employed reference temperature $T_0 = 293$ Kelvin ($+20^\circ\text{C}$), then the described measuring and billing method leads to
 10 completely correct results because then the unit volume V_E corresponds to a fluid unit mass M_0 which is exactly known in respect of its value and which is always the same. To ascertain the fluid mass $M_{\text{consumption}}$ which has flowed through the flow rate meter between two counter status reading operations, it is then sufficient to multiply the change in counter status that has occurred
 15 by the unit volume V_E in order to obtain a volume value which represents an exact measurement of the amount of fluid delivered to the consumer or the energy stored therein.

In the general case however neither the temperature or the pressure of the fluid are constant with sufficient accuracy. Thus the former can vary
 20 in a defined range, for example between 253 Kelvin and 333 Kelvin (between -20°C and $+60^\circ\text{C}$) while, when no particular measures are implemented, the pressure is related to atmospheric pressure which changes not only with the weather conditions but also depends on the height above sea level of the location at which the flow rate meter is used.

For the description hereinafter it is firstly assumed that technical
 25 measures ensure that the fluid pressure at the location of use of the flow rate meter is equal to a known constant reference pressure p_0 . The problem which then remains is that, in the delivery of the unit volume V_E to the consumer, that respectively triggers off a counting step, a fluid mass M_M
 30 which changes greatly with the temperature T_M prevailing at the respective measurement time is delivered so that simple multiplication of the count value and the unit volume V_E does not lead to usable results.

In other words: if the temperature T_M of the fluid at the measurement time is lower than T_0 , then the fluid is of greater density and a greater mass of fluid is delivered to the consumer per unit volume V_E , than at the reference temperature T_0 ; conversely, if the temperature T_M of the fluid at the measurement time is higher than T_0 , then the fluid is of lower density and the consumer receives a smaller mass of fluid per unit volume V_E .

In order nonetheless to be able to implement correct ascertainment of the delivered amount of fluid and to be able to express same in volume units, it is necessary, at least in each measurement value detection operation, to measure the absolute temperature T_M of the fluid and to take account thereof in forming the measurement value, in that, by means of the general gas equation, on the basis of the fluid mass M_M contained in the unit volume V_E at the temperature T_M , a delivery volume V_0 is calculated, which that mass M_M would have assumed if it had had the reference temperature T_0 when flowing through the flow rate meter.

In regard to the measurement temperature T_M , the following applies in accordance with the general gas equation:

$$(1) \quad p_M V_E = n_M R T_M$$

while in regard to the reference temperature T_0 the following applies:

$$(2) \quad p_0 V_0 = n_0 R T_0$$

wherein $n_M R$ stands for the fluid mass contained in the unit volume V_E at the measurement temperature T_M and $n_0 R$ stands for the fluid mass contained in the unit volume V_E at the reference temperature T_0 .

To obtain the above-described delivery volume V_0 corresponding to the fluid mass $n_M R$ equation (1) is divided by equation (2) and in accordance with the measurement principle $n_M R$ is made equal to $n_0 R$ and, because the pressure p is assumed to be constant, it is deemed that $p_M = p_0$, and this gives:

$$(3) \quad V_0 / V_E = T_0 / T_M$$

Equation (3) can be resolved in accordance with the delivery volume V_0 of interest:

$$(4) \quad V_0 = V_E T_0 / T_M$$

By means of a processor or a computing circuit it would therefore be readily possible at each measurement time to calculate from the measured temperature T_M the delivery volume V_0 corresponding to the fluid mass M_M which has just flowed through, as a multiple or part of V_E , as T_0 is an established constant.

Now, it is not only desirable but often essential for safeguard reasons for the measurement and storage procedures in respect of flow rate meters to be implemented independently of an external power supply or battery as the former is not available in manipulation-safeguarded fashion at any time at every measurement location and the use of the latter involves a high level of checking complication and expenditure and entails functional safeguard problems.

In accordance with the invention therefore the energy required for the measurement and storage procedures is obtained from the kinetic energy of the fluid by means of an autonomous position sensor which can be in the form of a linear sensor or revolution counter, as is described for example in DE 10 2007 039 050 A1.

For that purpose there is provided an exciter magnet system which for example in the case of bellows-type meters is either reciprocated with the sliders or is mounted on a rotor which is caused to rotate by way of a crankshaft arrangement or the like, by the fluid flow to be detected. It is crucial that there is an exact correlation between the fluid volume which has flowed through the flow rate meter or its measurement chamber or chambers and the portions of motion through which the exciter magnet system has passed.

The following description refers to a preferred situation where the exciter magnet system is mounted on a rotor and is thus part of a revolution counter. The method according to the invention however is not restricted thereto and can be used in an entirely similar fashion if the number of fluid unit volumes V_E delivered is measured by means of a linear sensor arrangement. The fluid unit volume V_E is different from one device to another and has to be determined in a calibration operation. The device-

specific calibration constant resulting therefrom is contained in the respectively employed V_E .

Whenever the rotor of the rotary sensor variant has passed through a predeterminable angle segment $\Delta\phi_M$ which can be for example of a value of 360°, measurement value detection takes place. The corresponding moment in time is referred to herein as the measurement time. However any other values, in particular 180° or 60°, can also be adopted for the angle segment $\Delta\phi_M$. At any event a fluid unit volume V_E defined by the size of the measurement chamber or chambers must flow through the flow rate meter so that the rotor rotates through the angle segment $\Delta\phi_M$.

As a Wiegand or pulse wire with a coil wound on the wire is so arranged in the field of the exciter magnet system that at least whenever the rotor or the flow rate meter has passed through the angle segment $\Delta\phi_M$, that is to say at each measurement time, a measurement voltage pulse is generated in the coil, at least a first energy storage means of an energy storage unit can be charged up, which supplies energy to a temperature measuring unit serving to measure the fluid temperature, a non-volatile storage means in which the measurement values are formed or stored, and at least a part of a corresponding electronic control and processing means, at least until the respective last measurement value is reliably stored.

It will be noted however that the electric energy branched from the kinetic energy of the fluid in that way in the individual voltage pulses is not sufficient at the time to operate at each measurement time a processor, by means of which the division shown in equation (4) and required in each measurement value detection operation by T_M can be performed.

In accordance with a first aspect of the invention therefore the division which is actually required when using a temperature sensor with an output voltage directly proportional to the absolute temperature T_M , in accordance with equation (4), is converted by a mathematical approximation method into summing of whole numbers, which can be effected without the assistance of a processor with a logic control means which has only a low energy requirement and can therefore be fed from the energy of a single voltage pulse.

If in equation (4) T_M is replaced by $T_0 \pm \Delta T$, that gives:

$$(5) \quad V_0 = V_E \frac{T_0}{T_0 \pm \Delta T} = V_E \frac{1}{1 \pm \frac{\Delta T}{T_0}}$$

If ΔT is small in comparison with T_0 , then the following approximately applies:

$$5 \quad (6) \quad V_0 \approx V_E \left(1 \mp \frac{\Delta T}{T_0}\right)$$

or

$$(7) \quad V_0 T_0 \approx V_E (2T_0 - T_M)$$

Since, as already mentioned, in the case of a flow rate meter operating in accordance with the invention, the measurement temperature T_M can vary for example between 253 Kelvin and 313 Kelvin, the condition that ΔT is to be small in comparison with T_0 does not apply in the entire temperature range, and it is necessary to introduce a correction constant $p \leq 1$:

$$(8) \quad V_0 \frac{T_0}{V_E} \approx \left(1 + \frac{1}{p}\right) T_0 - p T_M$$

15 For the fluid delivery volume $V_{consumption}$ which is relative, that is to say which is related to the fluid unit volume V_E , which has flowed through the flow rate meter in a period of time in which r measurement value detection operations have taken place, the following then applies:

$$(9) \quad V_{consumption} T_0 \approx r \left(1 + \frac{1}{p}\right) T_0 - \sum^r p T_M$$

20 If, to achieve integral temperature measurement values, a constant α representing the resolution of temperature measurement is introduced, then equation (9) can be transformed into:

$$(10) \quad \alpha \frac{V_{consumption} T_0}{p} \approx r \alpha \left(\frac{1+p}{p^2}\right) T_0 - \sum^r \alpha T_M$$

or, as T_0 , α and ρ are known constant parameters so that $\alpha T_0/\rho$ can be referred to as the first constant K_1 and $(1+\rho)T_0\alpha/\rho^2$ can be referred to as the second constant:

$$(11) \quad V_{consumption} K_1 \approx rK_2 - \sum \alpha T_M$$

5 or alternatively

$$(12) \quad V_{consumption} K_1 \approx \sum (K_2 - \alpha T_M).$$

In both cases admittedly the product αT_M must be formed in each measurement time by means of the available energy of a single pulse of the coil wound around the Wiegand or pulse wire, which however can be effected
10 by means of an analog/digital converter involving a low power requirement, with the resolution capability α , which directly supplies that product when it is fed with the analog signal supplied by a linearly operating temperature sensor.

α specifies how far the unit, for example Kelvin, is resolved. With a
15 resolution of 0.1 Kelvin, $\alpha = 10$.

When using equation (11) it is therefore sufficient for the integral values αT_M respectively occurring at the measurement times to be stored as an ongoing sum in a non-volatile storage means and for the counter status of a non-volatile counter to be increased by 1 in order to store the number r
20 of the measurement value detection operations effected in a time interval considered.

The ongoing sum and the counter status r of the non-volatile counter can then be passed at any selectable transmission times to a processor which is preferably supplied by means of external energy and which converts
25 it into the respective delivery volume $V_{consumption}$. Those transmission or reading-out processes correspond to the operations of reading off the known mechanical counting mechanisms, set forth in the opening part of this specification, and they can also be effected in fixedly predetermined time intervals. As however there is no need for them to be carried out by an
30 operator going to the flow rate meter in question, substantially shorter spacings in respect of the transmission times are also possible. They can

either be predetermined in accordance with a fixed time pattern and/or they can be triggered by a demand on the part of the receiver side or the consumer.

As a flow rate meter according to the invention is protected from manipulation operations from the exterior, it is possible in principle for the ongoing sum in the non-volatile storage means and the counter status r of the non-volatile counter to be set back to zero after each transmission to the processor. That gives the advantage that the respective delivery volume $V_{\text{consumption}}$ directly denotes the amount of fluid which has flowed to the consumer since the preceding transmission time.

Extrapolation of the amount of fluid delivered to the consumer since the beginning of supply is possible as the normal situation with the method according to the invention in that the ongoing sum and the count value r are not reset either at the flow rate meter itself or at the receiver of the transmitted data.

The time interval which precedes the respective transmission time and for which the processor calculates the mass of fluid which has flowed through the flow rate meter is therefore either the time interval which has elapsed between the last and the penultimate transmission time or it is the time interval which has elapsed from the beginning to the last transmission time.

When using equation (12) the decimal places of K_2 can be disregarded without major error so that the values $K_2 \cdot \alpha T_M$ which respectively occur at the measurement times are whole numbers and can be stored in the non-volatile storage means as an ongoing sum. Difference formation can be implemented with a computing system involving a low level of power requirement. Detection and storage of the count value r is not required here. Definitive calculation of the delivery volume $V_{\text{consumption}}$ is again effected at the end of the time interval being considered, after reading off just the ongoing sum which is divided by K_1 by means of a processor supplied with external energy.

In the equations (8) to (12), the " $\approx$ " sign can be replaced by the " $=$ " sign if levels of accuracy $\geq 0.5\%$ are admissible.

Another possible way of producing the values to be stored in the non-volatile storage means as an ongoing sum involves using a non-linear temperature sensor which supplies an output voltage U_M inversely proportional to the temperature T_M , as is possible for example by means of
 5 an NTC suitably connected to additional resistors.

Equation (4) then becomes:

$$(13) \quad V_0 = V_E T_0 U_{TM}$$

or, if U_{Mmin} denotes the voltage value occurring at the lowest temperature to be measured and the currently measured temperature T_M is represented by
 10 $U_{Mmin} + \Delta U_{TM}$:

$$(14) \quad \frac{V_0}{V_E T_0} = U_{TM} = U_{min} + \Delta U_{TM}$$

The operation of ascertaining the delivery volume $V_{consumption}$ is then effected in accordance with the equation:

$$(15) \quad K_4 V_{consumption} = r \alpha U_{min} + \sum^r \alpha \Delta U_{TM}$$

15 (with counting of the measurement value detection operations per time interval considered and storage and transmission of the counter status r in question) or in accordance with equation:

$$(16) \quad K_4 V_{consumption} = \sum^r (\alpha U_{min} + \alpha \Delta U_{TM}) = \sum^r \alpha U_{tm}$$

(without counting of the measurement value detection operations per time
 20 interval considered and without production, storage and transmission of a corresponding counter status r)

If the detected and stored value or values has or have been passed to a processor supplied with external energy it can ascertain the delivery volume $V_{consumption}$ of interest in the case of equation (15) from the
 25 continuously stored sum $\sum^r \alpha \Delta U_{TM}$ by the addition of $r \alpha U_{Mmin}$ and division by

K_4 , wherein $K_4 = \alpha/V_E T_0$. When using equation (16) only the ongoing sum $\sum^r \alpha U_{TM}$ is communicated to the processor and divided by K_4 thereby.

In this case also α is a factor which ultimately does not influence the

measurement value and which only serves to produce whole numbers from the measurement values ΔU_M occurring under some circumstances as multiples of fractions of a degree. If the measurement values ΔU_M are obtained only in whole Celsius degree values, so $\alpha = 1$, if they are tenths of degree values $\alpha = 10$ and so forth.

If no device for keeping the fluid pressure constant is provided then it is measured in accordance with the invention. If U_{pM} is the voltage delivered by the pressure sensor used, then similarly to equation (13) that gives:

$$(17) \quad \frac{V_0 p_0}{V_E T_0} = U_{TM} U_{pM}$$

If in this case also two factors α and β corresponding to the degree of measurement resolution are introduced, which produce integral values αU_{TM} and βU_{pM} from the voltage values U_{TM} and U_{pM} , then similarly to equation (16) that gives:

$$(18) \quad K_5 V_{\text{consumption}} = \sum \alpha \beta U_{TM} U_{pM}$$

wherein $K_5 = \alpha \beta p_0 / V_E T_0$. It is therefore sufficient with the energy available for each measurement pulse in the first energy storage means to form the product $\alpha U_{TM} \beta U_{pM}$ and to store it as the ongoing sum $\sum \alpha \beta U_{TM} U_{pM}$ in the non-volatile storage means, from which it can be passed to the processor supplied with external energy and which divides it by K_5 to obtain the delivery volume $V_{\text{consumption}}$ which is of interest and which is corrected both in relation to temperature changes and also pressure changes and which represents an accurate measurement of the fluid mass delivered to the consumer.

In the case of many flow rate meters the mechanical arrangement is such that the rotor can rotate only in one direction. In use situations in which rotor rotation is possible in both directions, a magnetosensitive element, for example a Hall element, is additionally arranged in the field of the exciter magnet system, the output signal of which serves for detecting the direction of rotation, as is described for example in DE 10 2008 051 479

A1 and which is also supplied with electric energy by the first energy storage means.

By means of a Hall element arrangement which can be supplied with external energy and which is equally arranged in the field of the exciter magnet system the angle segment $\Delta\phi_M$ can be finally resolved, as is known for example from above-mentioned DE 10 2007 039 050 A1. That fine resolution can be used for calibration purposes and/or for detecting leaks on the consumer side.

The exciter magnet system can include a plurality of permanent magnets so that the coil wound on to the Wiegand or pulse wire between the measurement voltage pulses delivers further voltage pulses which charge a further energy storage means in the form of an autonomous energy source of the energy storage unit, in which energy from a plurality of those further voltage pulses is cumulated, that energy being sufficient to send the value of the ongoing sum stored in the non-volatile storage means to a remotely arranged receiver, from time to time, at which there is then disposed the processor which is supplied with external energy and which performs the calculation of the delivery volume $V_{\text{consumption}}$. It is also possible for the further energy storage means of the energy storage unit even to supply energy to that processor or to a processor which is in the flow rate meter and which performs those calculations.

Preferably the exciter magnet system includes two permanent magnets with a shielding return body, as described in DE 10 2007 039 050 A1. That shielding means that the flow rate meter can be effectively protected from attempted manipulation which is effected by means of externally applied magnetic fields in order for example to inhibit or brake the movement of the exciter magnet system.

Preferably an FRAM storage means or an MRAM storage means is used as the non-volatile storage means.

These and further advantageous configurations of the method according to the invention are recited in the appendant claims.

The invention is described hereinafter by means of an embodiment by way of example with reference to the drawing; therein the single Figure

shows a schematic block circuit diagram of the most essential components, serving to carry out the method according to the invention, of a flow rate meter on the basis of an autonomous rotary sensor.

To be able to obtain the electric energy required for carrying out the necessary measurement and storage procedures from the kinetic energy of a flowing fluid, there is provided an exciter magnet system 1 which is represented in the Figure by a permanent magnet and which in the illustrated embodiment is mounted on a rotor of which only the axis of rotation 3 is indicated in the Figure. As indicated by the arrow R, the rotor is caused to rotate by the fluid flow to be detected, by means of a suitable mechanical device (not shown in the Figure), in such a way that there is an exact correlation between the fluid volume flowing through the flow rate meter or its measuring chamber or chambers, and the rotary angle covered by the rotor. Disposed in the field of the exciter magnet system 1 is a Wiegand arrangement comprising a Wiegand or pulse wire 5 and a coil 7 which is wound thereon and in which a voltage pulse is induced whenever the exciter magnet system 1 passes through certain angle positions. If the exciter magnet system 1 only consists of a single permanent magnet, then two such voltage pulses are obtained in each full revolution of the rotor, but it is possible for example for six or ten such pulses also to be produced in each full revolution by the use of a plurality of pairs of magnetic poles.

For the example described here it is assumed that one of the voltage pulses produced in the respective full revolution serves as a measurement voltage pulse, that is to say whenever the rotor has passed through an angle segment $\Delta\phi_M$ of 360° , corresponding to a unit volume V_E of the fluid that has flowed through the flow rate meter, the measurement and storage procedures described hereinafter are performed. The moment at which such a measurement voltage pulse occurs is referred to in the present context as the measurement time.

The circuit units shown in the Figure can be divided into two mutually partially overlapping groups 8 and 9, of which the first is enclosed by a rectangle shown in broken lines and the second is enclosed by a rectangle shown in dash-dotted lines.

Of the circuit units and components in the first group 8, the analog/digital converters 14 and 15 respectively associated with the temperature sensor 11 and the pressure sensor 12, the single Hall element 16 possibly provided for detecting the direction of rotation of the rotor, the counting and storage logic means 17, the non-volatile storage means 19 and the energy management circuit 20 operate each time that there occurs a measurement voltage pulse which charges a first energy storage means 22 which is formed in the Figure by a capacitor and which provides that the required electric working energy is available to the above-mentioned units sufficiently long that they ascertain the currently prevailing measurement values for the fluid temperature T_M and the fluid pressure p_M and digitize same and can store the integral count values βU_{pM} and αU_{TM} formed from those measurement values in the counting and storage logic means 17 as an ongoing sum in the non-volatile storage means 19, in which there is possibly also stored a counter status r which is ascertained by the counting and storage logic means 17 and which specifies what is the ordinal number of the measurement voltage pulse, that has occurred in a delivery time interval being considered.

Production of the ongoing sum is now to be elucidated by a numerical example for the situation where the pressure can be viewed as constantly equal to p_0 . If it is assumed that, by virtue of a suitable resolution on the part of the analog/digital converter 14, the temperature measurement value U_{TM} falls in tenths of a degree and is for example 293.5 Kelvin after passing through a full revolution of the rotor, triggering a measurement voltage pulse, that value is thus multiplied by $\alpha = 10$, thus giving an integral count value of 2935 which to form the ongoing sum is added to the numerical value (for example 576365) contained in the non-volatile storage means 19 so that the new ongoing sum now contained in the non-volatile storage means 19 is 579300. If then, when the next measurement voltage pulse occurs, the temperature has increased by two tenths of a degree to 293.7 Kelvin, then 2937 is obtained as the last integral count value and 582237 is obtained as the last ongoing sum.

In contrast to a conventional flow rate meter whose counting mechanism continues to count by "1" at each passage through the measurement angle segment $\Delta\phi_M$ of for example 360° , in accordance with the invention the ongoing sum in the non-volatile storage means 19 is
 5 increased on each occasion by an integral count value which changes in dependence on the fluid temperature prevailing at the measurement time so that that ongoing sum contains all items of information required to calculate the fluid mass delivered to the consumer. A corresponding consideration
 10 also applies in respect of changing pressure measurement values if the fluid pressure value U_{pM} detected at the respective measurement time can vary.

If it is assumed that the energy delivered by a measurement voltage pulse is just sufficient to perform the measurement and storage tasks described, which occur at each measurement time, it is then provided that the energy of voltage pulses which are produced between the measurement
 15 voltage pulses and which do not trigger any measurement and storage procedures of that kind is cumulated in a second energy storage means 23 which for example is also formed by a capacitor and which at selectable moments in time supplies energy to a transmitter 25 which can operate with radio frequency, infrared light, ultrasound or any other transmission energy,
 20 in order for example to wirelessly send the last value of the ongoing sum stored in the non-volatile storage means 19 and optionally the counter status r to a remotely arranged receiver at which then, with an external energy supply, implementation of the calculations required for ascertaining the fluid mass delivered to the consumer in a respective measurement time interval
 25 can be effected by means of a processor, a μ -controller, a computer or the like.

If however measurement voltage pulses contain more energy than is needed for the respectively occurring measurement and storage tasks, that excess energy can also be cumulated in the further energy storage means 23
 30 and used in the above-depicted fashion.

All circuit portions belonging to the first group 8 operate totally autonomously and do not require either a battery or any other external energy supply. Preferably they are combined together in an IC which can

also be in the form of a hybrid circuit. In particular the first energy storage means 22 can be integrated in that IC. In general the temperature sensor is a separate component.

In comparison, a supply with electric energy solely from the first energy storage means 22 is not adequate for the components or circuit units belonging to the second group 9, namely a Hall probe arrangement 30 including a plurality of Hall elements, a multiplexer 31 and an amplifier 32. They therefore require an additional energy source, as is also described in greater detail hereinafter.

The processor 33 shown in the Figure can either be a component of the circuit arrangement disposed directly at the flow rate meter; it is then either to be attributed to the group 9, or it is supplied with electric energy from the further energy storage means 23 so that, from the respectively last value of the ongoing sum stored in the non-volatile storage means 19, it calculates the corresponding values of the delivered mass of fluid and passes same to the transmitter 25 which then sends them for example wirelessly to a remotely arranged receiver. If a receiver can receive the data from a plurality of transmitters (network arrangement) then each of the transmitters sends a dispatcher address identifying it, together with the data required for calculating the delivery volume $V_{\text{consumption}}$.

In accordance with a further alternative the processor 33 can be identical to the above-mentioned processor which is arranged at a remotely disposed receiver and for which an external energy supply is provided in any case. The required data which are then transmitted also then include the constants K_1 to K_3 with the included calibration data.

The Hall probe arrangement, like the Wiegand or pulse wire 5 and the coil 7 wound thereon, is disposed in the field region of the exciter magnet system 1 and serves to cause fine resolution of the angle segments predetermined by the pairs of magnetic poles of the exciter magnet system 1, as is known from the above-mentioned state of the art (multi-turn). The multiplexer 31 serves for single-channel processing of the output signals of the individual Hall elements of the Hall probe arrangement 30, which are amplified in the subsequent amplifier 32 and then fed to the processor 33

which ascertains therefrom in per se manner fine angle values which more precisely describe the respective rotor position.

For the purposes of that fine resolution there is on the one hand facilitated calibration of the flow rate meter according to the invention, which
5 is implemented at the factory before first bringing the system into operation, in which case the external voltage V_{DD} is readily available.

In addition fine resolution can be used for tracing leaks, through which only very small amounts of fluid issue on the consumer side of the flow rate meter. For that purpose a maintenance operative supplies the circuit
10 arrangement of the flow rate meter with external energy for a period of time which for example can be of the order of magnitude of some minutes, and, by means of the fine resolution arrangement, observes whether the angular position of the rotor changes slightly, which points to the presence of a leak, or not. The "external energy" can be made available in the most widely
15 varying ways, for example by using a battery or a solar cell operated with ambient light.

Instead of the above-mentioned Hall elements or Hall probes, it is also possible to use other magnetosensitive components, GMR-sensors (GMR – giant magneto resistance).

20 For reasons of space and costs, implementation of the apparatus according to the invention is generally preferred with a single Wiegand module, comprising a Wiegand or pulse wire with a coil wound thereon. It is however also possible to envisage solutions with two or more Wiegand modules in place of a Wiegand module supplemented by an additional
25 magnetosensitive element.

Claims

1. Method for determining the mass of a fluid flowing through a flow rate measurement device, the absolute temperature T_M of which fluid may fluctuate in a designated temperature range, for which fluid an exciter magnet system (1) having at least one exciter magnet is driven by the flowing fluid such that a precise correlation between the through-flowing fluid volume and the movement distance passed through by exciter magnet system (1) exists, and a measurement voltage impulse is generated always at the time when the exciter magnet system (1) has passed through a preselectable movement distance that corresponds to a standard volume V_E of the fluid, characterized in that

- the measurement voltage impulse is generated by means of at least one Wiegand and/or impulse wire (5) that is arranged in the field of the exciter magnet system (1), and a coil (7) wound up on the wire,
- that a first energy storage (22) as an autarkical energy source in an internal energy storage unit is charged respectively at the occurrence of a measurement voltage impulse, which occurrence defines a time point of measurement, with electric energy contained in this voltage impulse, and
- that at each time point of measurement, energy that is contained in the first energy storage (22) is used as operation energy for the following processes:
 - o measuring the current absolute temperature T_M and/or a quantity U_{TM} of the fluid that passes through the flow rate measurement device, which quantity is derived from the absolute temperature, using a temperature measurement device,
 - o multiplying the current absolute temperature T_M by a constant α , which is selected according to the resolution of the current absolute temperature T_M such that a whole-number temperature value αT_M is formed, and generating a whole-number count value $\{K_2 - \alpha T_M\}$, for which is $K_2 = (1 + \rho) T_0 \alpha / \rho^2$, ρ means a suitably selected correction constant ≤ 1 , and T_0 is a fixed constant and/or multiplying the quantity U_{TM} derived from the absolute temperature T_M by a constant α , which is selected according to the resolution of the

current absolute temperature T_M such that a whole-number value αU_{TM} derived from the temperature is formed,

- for each r acquisition, adding the whole-number count value $\{K_2 - \alpha T_M\}$ and/or αU_{TM} to a sum of the precedingly determined count values, which sum is contained in a non-volatile memory (19), for forming a consecutive sum $\sum^r (K_2 - \alpha T_M)$ and/or $\sum^r \alpha U_{TM}$
- and forwarding of the consecutive sum $\sum^r (K_2 - \alpha T_M)$ and/or $\sum^r \alpha U_{TM}$, at selectable time points of transmission, to a processor (33) that can be supplied with external energy, for calculating the temperature-corrected delivery volume $V_{Consumption}$ of the fluid, which delivery volume corresponds to the mass of the fluid that has passed through the flow rate measurement device.

2. Method according to claim 1, characterized in that, using energy contained in the first energy storage (22), at each time point of measurement, in addition the following steps are performed:

- measuring the pressure (p_M) that prevails in the standard volume using a pressure measurement device (12),
- generating a pressure value βU_{pM} as a whole-number multiple of the smallest resolvable pressure measurement unit and
- generating a whole-number count value $\alpha \beta U_{TM} U_{pM}$ as the product of the temperature value αU_{TM} and the pressure value βU_{pM} ,
- adding the whole-number count value $\alpha \beta U_{TM} U_{pM}$ to a sum of the precedingly determined count values, which sum is contained in the non-volatile memory (19), for forming a consecutive sum $\sum^r \alpha \beta U_{TM} U_{pM}$ that is stored in the non-volatile memory (19) and
- at selectable time points of transmission, forwarding the consecutive sum $\sum^r \alpha \beta U_{TM} U_{pM}$ that is stored in the non-volatile memory to a processor (33) that can be supplied with external energy, which processor calculates, using the known constants (α , β , p_0 , T_0 , V_E), the temperature- and pressure-corrected delivery volume $V_{Consumption}$ of the fluid, which delivery volume corresponds to the mass of the fluid that has passed through the flow rate measurement device.

3. Method according to claim 1, characterized in that the current temperature is measured by means of a temperature sensor (11), the output voltage of which is directly proportional to the absolute temperature T_M .
4. Method according to claim 1 or 2, characterized in that the quantity that is derived from the current absolute temperature is the output voltage U_{TM} of a temperature sensor (11), which output voltage is inversely proportional to this temperature.
5. Method according to claim 1 or 3, characterized in that the whole-number count value consists only of the temperature value αT_M and/or the value of the quantity $\alpha \Delta U_{TM}$ derived from the temperature, and in that the measurement voltage impulses are counted in addition, and the counter reading r is also transmitted to the processor (33) that can be supplied with external energy and is used by the latter for calculating the temperature-corrected delivery volume.
6. Method according to any one of **claims 1 through 5**, characterized in that the rotation direction of the rotor is measured by means of the output signal of a Hall element (16) that is supplied with electric energy from the first energy storage (22) of the internal energy storage unit.
7. Method according to any one of **claims 1 through 6**, characterized in that the analogue output signal of the temperature sensor (11), which signal changes with the temperature T_m , is transformed into the whole-number value, which can be supplied to the count and storage logic (17), with the according resolution α by means of an analogue-to-digital converter (14) that belongs to the temperature measurement unit
8. Method according to any one of the claims 2 to 7, characterized in that the analogue output signal of the pressure sensor (12), which signal changes with the pressure p_m , is transformed into the whole-number value, which can be supplied to the count and storage logic (17), with the according resolution β by means of an analogue-to-digital converter (15) that belongs to the pressure measurement unit.

9. Method according to any one of **claims 1 through 8**, characterized in that a fine resolution of the measurement angle is performed by means of a measurement and processing arrangement (30, 31, 32, 33), for the supply of which with electric energy an external voltage V_{DD} can be applied to the flow rate measurement device.
10. Method according to claim 9, characterized in that the fine resolution of the measurement angle is used for a calibration of the flow rate measurement device and/or for a recognition of leakages in the flow path present behind the flow rate measurement device.
11. Method according to any one of **claims 1 through 10**, characterized in that the exciter magnet system has at least two exciter magnets that are shielded to the outside by a ferromagnetic return body such that further voltage impulses are induced between the measurement voltage impulses in the coil (7) that is wound up on the Wiegand and/or impulse wire (5), wherein the energy of the further voltage impulses is accumulated in a further energy storage (23) of the energy storage unit in order to send the last value of the consecutive sum that is stored in the non-volatile memory (19) to a receiver arranged remotely.
12. Method according to any one of **claims 1 through 11**, characterized in that an additional magneto-sensitive element is arranged in the field of the exciter magnet system, wherein the output signal of the magneto-sensitive element serves for recognition of the rotation direction.
13. Device for performing the method according to any one of **claims 1 through 12**.

