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(54) **CONTROL METHOD FOR A RAPID HEATING APPARATUS FOR LIQUIDS, AND CORRESPONDING RAPID HEATING APPARATUS**

(57) Control method for a rapid heating apparatus (10) for liquids, comprising a rapid heating unit (18), a flowmeter (15) able to measure a flow of liquid in the rapid heating unit (18), a detection and control device (20) configured to cooperate with the flowmeter (15) in order to detect a proximity signal (34) correlated to said flowmeter (15) with respect to said detection and control device (20), and to supply a possible indication of the malfunctioning or damage of the flowmeter (15).

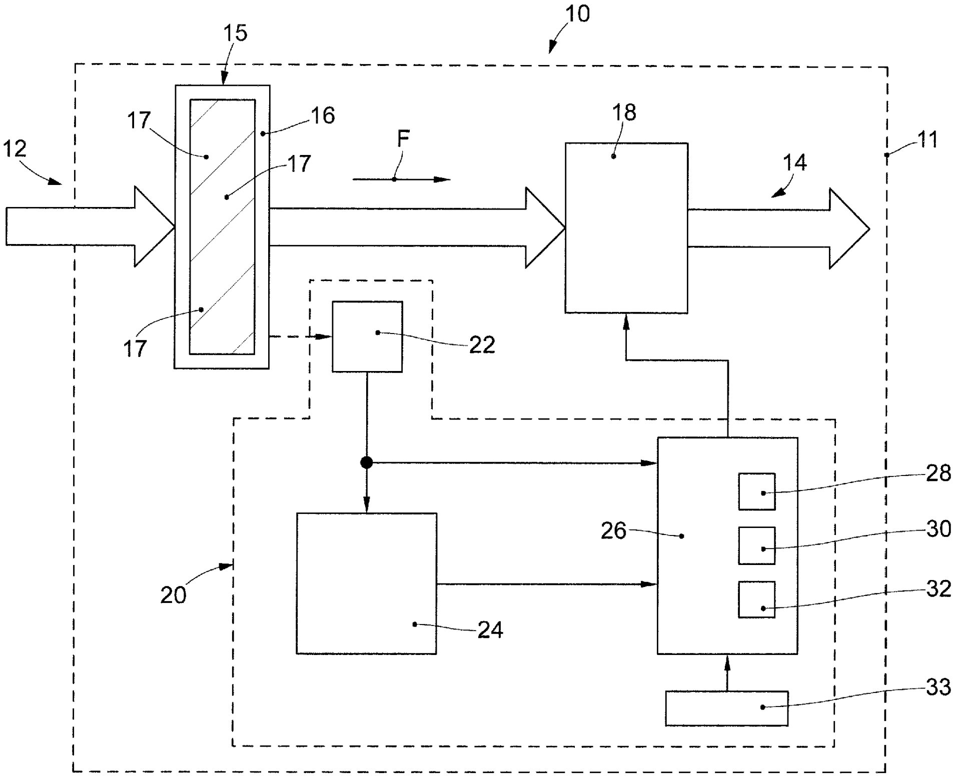

fig. 1

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Description

FIELD OF THE INVENTION

[0001] Embodiments described here concern a control method for a rapid heating apparatus for liquids, and corresponding rapid heating apparatus.

BACKGROUND OF THE INVENTION

[0002] Rapid heating apparatuses for liquids are known, used for example in domestic appliances, or in swimming pools, to supply domestic hot water in short times, for example for shower systems but also wash basins or similar bathroom fixtures.

[0003] Typically these rapid heating apparatuses, often also called instantaneous heaters, can be gas-powered, like boilers, or electric heaters, which typically use electric resistances. In this latter case, the electric resistances are generally housed in plastic casings where the water to be instantaneously heated flows.

[0004] It is provided to use a flowmeter with a turbine coated with a conductive material to monitor the flow of water, which operates in combination with a device to convert an inductance-digital signal which generates a signal with a frequency based on the position of the turbine with respect to a coil that is excited.

[0005] Usually, to monitor the functioning of the rapid heating apparatus for liquids, typical physical parameters are monitored, analyzing their development over time and finding the necessary information from this analysis. To guarantee the good functioning of the heater, it is important that there are no errors in the detection of the data, since these situations can lead to measuring a flow which is different, even very different, from the real flow, and hence the heating control system works abnormally, which can lead to serious problems in the functioning of the heater, with risks of explosions or fires.

[0006] To try to prevent these malfunctions, which can be extremely dangerous for the user, rather laborious and complex solutions have been proposed to control the heating, based on detection of the temperature of the water at entrance and exit, the power absorbed, a measurement of the flow and other operating parameters, which are not simple to implement and in any case do not guarantee to detect the specific problem deriving from an incorrect functioning of the rapid heating apparatus for liquids. In this way, there is a risk of detecting an error in the flow even when the flow is adequate, or vice versa.

[0007] Moreover, these solutions proposed in the state of the art are not able to detect whether the rotor of the turbine is malfunctioning or damaged, and to discriminate this case from the case of a hypothetical variation in the flow. This is disadvantageous because, if a variation in the signal associated with the rotor were erroneously associated with a hypothetical variation in the flow, and not, in reality, with a malfunction or damage of the rotor of the turbine, then the temperature control would also be incorrect.

[0008] Document DE-A-10231692 describes a method to detect air bubbles inside a water heater apparatus. The apparatus provides that, after the tap has been opened at time t0, the heater is not activated until the flow of water has reached a set value. Rapid fluctuations in the fluid that drives the flowmeter, due to the possible presence of air bubbles, induce a characteristic development of the flow shaped like a segmented tooth. During a period Ts, corresponding to the time in which the heater can be activated safely with zero flow, a microprocessor analyzes the resultant wave forms to determine whether the difference between the maximum and minimum peaks of the wave form indicates absence of air and hence whether to continue using the apparatus is safe. The method is based in particular on the analysis of a signal arriving from the rotor of the flowmeter, evaluating the sudden variations of the signal in the determinate period Ts, observing the slope of the signal. In substance, the known method provides to verify if the flow of water measured varies suddenly and frequently in a determinate period of time in an anomalous manner, using reference thresholds, such as to impute the variations to the presence of air bubbles and not to a normal variation in the flow of water. Therefore, this known solution too is unable to detect whether the rotor of a turbine associated with the flowmeter is malfunctioning or damaged, with all the disadvantages described above.

[0009] Document US-A-2011/027680 is also known, which describes a fuel cell system which provides to measure the exact quantity of the flow of oxidant air which, together with the fuel, is supplied to the fuel cell system. The flow of air containing oxygen is controlled by a mass flowmeter or volume flowmeter.

[0010] Other limitations and disadvantages of conventional solutions and technologies will be clear to a person of skill after reading the remaining part of the present description with reference to the drawings and the description of the embodiments that follow, although it is clear that the description of the state of the art connected to the present description must not be considered an admission that what is described here is already known from the state of the prior art.

[0011] There is therefore a need to perfect a control method for a rapid heating apparatus for liquids and a corresponding rapid heating apparatus that can overcome at least one of the disadvantages of the state of the art.

[0012] In particular, one purpose of the present invention is to obtain a control method for a rapid heating apparatus for liquids and a corresponding rapid heating apparatus for liquids which implements said method, which can be used to detect the flow of liquid in cooperation with a flowmeter and recognize, simply, practically and precisely, possible malfunctions or damage of the rotor of the turbine in the flowmeter.

[0013] Another purpose of the present invention is to obtain a rapid heating apparatus for liquids that is long-lasting, reliable and economical.

[0014] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0015] The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

[0016] Embodiments described here concern a control method for a rapid heating apparatus for liquids. In accordance with one embodiment, the control method includes:

- detecting, using a detection and control device, a proximity signal correlated to a flowmeter able to measure a flow of liquid in a rapid heating unit of the rapid heating apparatus, and provided with a turbine with a rotor, in which the proximity signal is a signal generated by the cooperation of proximity between a sensor element and the turbine of the flowmeter;
- analyzing a temporal development of the proximity wave form of the proximity signal;
- defining a lower threshold and an upper threshold in the temporal development of the proximity wave form;
- defining, in the temporal development of the proximity wave form, as a low peak a peak whose maximum is below the lower threshold and as a high peak a peak whose maximum is above the upper threshold;
- detecting and counting the number of high peaks and the number of low peaks inside a period, or a whole multiple of the period, of the temporal development of the proximity wave form of the proximity signal;
- if the number of low peaks in the period is greater, possibly by a defined margin of tolerance, than the number of high peaks, supplying an indication of malfunctioning or damage of the rotor of the turbine of the flowmeter.

[0017] In accordance with a possible embodiment, analyzing the proximity signal provides to sample the proximity signal with a suitable sampling frequency.

[0018] In accordance with another possible embodiment, defining the low peaks and the high peaks provides to detect the points of relative maximum of the proximity signal at entrance and to recognize, among the points of relative maximum, the primary points of maximum as the relative maximums of the proximity signal at entrance each time the upper threshold is exceeded, associating them with the high peaks, and secondary points of maximum as the relative maximums of the proximity signal at entrance when this falls below the lower threshold, associating them with the low peaks.

[0019] In accordance with yet another possible embodiment, the generation of the proximity signal occurs by exciting a coil of the sensor element, producing a magnetic field that induces eddy currents in a conductive coating of the turbine and detecting the variations of the eddy currents due to the rotation of the turbine.

[0020] In accordance with another embodiment, defining the lower threshold and the upper threshold comprises processing the proximity signal, setting the lower threshold and the upper threshold comprised between the minimum value and the maximum value of the proximity signal at entrance, wherein a suitable value is attributed to the upper threshold, greater than that of the lower threshold.

[0021] In accordance with yet another variant embodiment, the method provides to detect when the proximity signal at entrance increases above the value of the upper threshold and when it decreases below the value of the lower threshold, and to generate a correlated output signal in the form of a square wave.

[0022] In accordance with another possible embodiment, as a function of the indication of malfunctioning or damage of the flowmeter, it comprises supplying an alarm signal, or adjusting or interrupting the functioning of the heating unit.

[0023] Other embodiments described here concern a rapid heating apparatus for liquids. In accordance with one embodiment, the rapid heating apparatus for liquids comprises:

- a rapid heating unit,
- a flowmeter able to measure a flow of liquid in the rapid heating unit and provided with a turbine with a rotor;
- a detection and control device comprising at least a sensor element configured to cooperate in proximity with the turbine of the flowmeter in order to generate a proximity signal, the detection and control device being configured so as to:
- detect the proximity signal correlated to the flowmeter with respect to the sensor element of the detection and control device,
- analyze a temporal development of the proximity wave form of the proximity signal,
- detect and count inside a period, or a whole multiple of the period, of the temporal development of the proximity wave form of the proximity signal, the number of high peaks and the number of low peaks, where in the temporal development of the proximity wave form a peak whose maximum is below a lower threshold is defined as a low peak, and a peak whose maximum is above an upper threshold is defined as a high peak, wherein the lower threshold and the upper threshold are defined in the temporal development of the proximity wave form;
- supply an indication of malfunction or damage of the rotor of the turbine of the flowmeter, if the number of

low peaks in the period considered is greater, possibly by a defined margin of tolerance, than the number of high peaks.

[0024] In accordance with a possible embodiment, the turbine is coated with a conductive material and the detection and control device comprises at least a sensor element configured to cooperate with the turbine so as to generate the proximity signal, at least a signal converter device and at least a signal processing and control unit.

[0025] Still other embodiments described here concern a computer program memorizable in a computer-readable mean that contains the instructions which, once carried out by an apparatus as in the embodiments described here, determine the execution of the method in accordance with the present description.

[0026] These and other aspects, characteristics and advantages of the present disclosure will be better understood with reference to the following description, drawings and attached claims. The drawings, which are integrated and form part of the present description, show some forms of embodiment of the present invention, and together with the description, are intended to describe the principles of the disclosure.

[0027] The various aspects and characteristics described in the present description can be applied individually where possible. These individual aspects, for example aspects and characteristics described in the attached dependent claims, can be the object of divisional applications.

[0028] It is understood that any aspect or characteristic that is discovered, during the patenting process, to be already known, shall not be claimed and shall be the object of a disclaimer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] These and other characteristics of the present invention will become apparent from the following description of some embodiments, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a block diagram of a rapid heating apparatus for liquids in accordance with embodiments described here;
- fig. 2 is a block diagram of a signal converter device associable with a sensor element usable in a rapid heating apparatus for liquids in accordance with embodiments described here;
- fig. 3 is a diagram that shows embodiments of a processing of a signal by a signal converter device of a rapid heating apparatus in accordance with embodiments described here;
- fig. 4 is a possible wave form detected in accordance with embodiments described here;
- fig. 5 is another possible wave form detected in accordance with embodiments described here.

[0030] To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one embodiment can conveniently be incorporated into other embodiments without further clarifications.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

[0031] We shall now refer in detail to the various embodiments of the present invention, of which one or more examples are shown in the attached drawing. Each example is supplied by way of illustration of the invention and shall not be understood as a limitation thereof. For example, the characteristics shown or described insomuch as they are part of one embodiment can be adopted on, or in association with, other embodiments to produce another embodiment. It is understood that the present invention shall include all such modifications and variants.

[0032] Before describing these embodiments, we must also clarify that the present description is not limited in its application to details of the construction and disposition of the components as described in the following description using the attached drawings. The present description can provide other embodiments and can be obtained or executed in various other ways. We must also clarify that the phraseology and terminology used here is for the purposes of description only, and cannot be considered as limitative.

[0033] Embodiments described here concern a control method for a rapid heating apparatus 10 for liquids. According to the present description, the method provides:

- to detect, by means of a detection and control device 20, a proximity signal 34 correlated to a flowmeter 15 able to measure a flow of liquid in a rapid heating unit 18 of the rapid heating apparatus 10, and provided with a turbine 16 with a rotor, wherein the proximity signal 34 is a signal generated by the proximity cooperation between a sensor element 22 and the turbine 16 of the flowmeter 15;
- to analyze a temporal development of the proximity wave form of the proximity signal 34;
- to define a lower threshold 42 and an upper threshold 44 in the temporal development of said proximity wave form;
- to define, in the temporal development of the proximity wave form, as a low peak a peak whose maximum is below the lower threshold 42 and as a high peak a peak whose maximum is above the upper threshold 44;
- to detect and count the number of high peaks and the number of low peaks inside a period T, or a whole multiple of said period T, of the temporal development of the proximity wave form of the proximity sig-

nal 34;
- if the number of low peaks in the period T considered, or its whole multiple, is greater, possibly by a defined margin of tolerance, than the number of high peaks, to supply an indication of malfunctioning or damage of the rotor of the turbine 16 of the flowmeter 15.

[0034] Other embodiments described here concern a rapid heating apparatus 10 for liquids comprising:

- a rapid heating unit 18,
- a flowmeter 15 able to measure a flow of liquid in the rapid heating unit 18;
- a detection and control device 20 configured to co-operate with the flowmeter 15 provided with the tur-bine 16 with the rotor so as to:
- detect a proximity signal 34 correlated to the flowmeter 15 with respect to the detection and control device 20,
- analyze a temporal development of the proximity wave form of the proximity signal 34,
- detect and count, inside a period T, or a whole multiple of said period T, of the temporal development of the proximity wave form of the proximity signal 34, the number of high peaks and the number of low peaks, where in the temporal development of the proximity wave form a peak whose maximum is below a lower threshold 42 is defined as a low peak, and a peak whose maximum is above an upper threshold 44 is defined as a high peak, wherein the lower threshold 42 and the upper threshold 44 are defined in the temporal development of the proximity wave form;
- supply an indication of malfunction or damage of the rotor of the turbine 16 of the flowmeter 15, if the number of low peaks in the period T considered, or its whole multiple, is greater, possibly by a defined margin of tolerance, than the number of high peaks.

[0035] Fig. 1 is used to describe example embodiments of the rapid heating apparatus 10 for liquids usable in association with a control method according to the present description.

[0036] According to some embodiments, the rapid heating apparatus 10 is configured to heat a liquid rapidly, or instantaneously, such as for example water, although it is not excluded that it can be used to heat other types of liquid. Throughout the description, using the term liquid we mean any type of liquid or mixture of one or more types of liquid suitable to be heated, merely by way of example a liquid could possibly be water.

[0037] According to embodiments described using fig. 1, the rapid heating apparatus 10 can comprise for example electric resistances to heat a liquid rapidly, such as for example water, which by way of example can be supplied by a traditional water supply network. In the embodiments described here, by the expression "rapid" or "instantaneous" we mean, for example, that the rapid heating apparatus 10 is suitable to heat, for example water, supplied at a temperature for example from about 11 °C to 21 °C from the water mains, to a temperature for example of about 30-50°C in a few seconds. It is understood that the rapid heating apparatus 10 can also be kept temporarily inactive and hence not change the temperature of the liquid flowing through it.

[0038] According to embodiments described using fig. 1, the rapid heating apparatus 10 comprises a containing body 11 provided with a liquid entrance zone 12 and at least one liquid exit zone 14.

[0039] The rapid heating apparatus 10 can be defined by walls inside which a liquid flows.

[0040] According to some embodiments, the rapid heating apparatus 10 for liquids can be associated, by means of the entrance zone 12, with a pipe, located upstream in the direction of the arrow F, which allows the liquid to be heated to enter into the rapid heating apparatus 10.

[0041] According to other embodiments, the rapid heating apparatus 10 for liquids can be associated by means of the exit zone 14 with a pipe, located downstream in the direction of the arrow F, which allows the heated liquid to exit from the rapid heating apparatus 10.

[0042] In embodiments described using fig. 1, the flowmeter 15 is configured to measure the flow of the liquid entering into the rapid heating apparatus 10.

[0043] In particular, the flowmeter 15 can include at least the turbine 16. The turbine 16 can be coated with a conductive coating, suitable to supply a signal that can be detected by the detection and control device 20.

[0044] According to some embodiments, the turbine 16 comprises a rotor provided peripherally with a plurality of blades 17, disposed radially and preferably equidistant from each other, so as to separate the passage of liquid regularly.

[0045] The rapid heating unit 18 is configured to raise the temperature of the liquid that passes through the flowmeter 15 and therefore the rapid heating apparatus 10, supplying the liquid to the users at the desired temperature.

[0046] Advantageously, the flowmeter 15 is situated upstream of the rapid heating unit 18, according to arrow F, so that the flow of liquid is detected before the liquid passes through the rapid heating unit 18, so as to anticipate the regulation and/or de-activation of the latter by the detection and control device 20 if a regulation signal is detected, supplied for example by a user, or an anomalous signal or malfunction signal.

[0047] According to variant embodiments described using fig. 1, the detection and control device 20 can be provided with at least a sensor element 22 configured to cooperate with the turbine 16, so as to generate the proximity signal 34.

[0048] Moreover, the detection and control device 20 can be provided with at least one signal convertor device 24.

[0049] Furthermore, the detection and control device

20 can be provided with at least a signal processing and control unit 26, configured to perform analysis and processing of the signal of the method according to the present description.

[0050] In possible embodiments, combinable with all the embodiments described here, the signal processing and control unit 26 can include a microcontroller, or system controller.

[0051] In possible embodiments, combinable with all the embodiments described here, the signal processing and control unit 26 can include a central processing unit or CPU 28, an electronic memory 30, an electronic data base 32 and auxiliary circuits (or I/O) (not shown).

[0052] For example, the CPU 28 can be any form of computer processor used in the IT and/or automation field. The electronic memory 30 can be connected to the CPU and can be one of those commercially available, such as a random access memory (RAM), a read-only memory (ROM), floppy disk, hard disk, mass memory or any other form of digital archive, local or remote. The software instructions and data can be for example encoded and memorized in the electronic memory 30 to command the CPU 28. The auxiliary circuits can also be connected to the CPU 28 to assist the processor in a conventional manner. The auxiliary circuits can include for example at least one of: cache circuits, feed circuits, clock circuits, input/output circuits, subsystems and suchlike. Parameters and data usable to implement the embodiments described here of the method according to the present description can be memorized in the electronic data base 32. For example, the values of the lower threshold 42 and upper threshold 44 can be memorized in the electronic data base 32, and possibly also the value of the margin of tolerance. A computer-readable program (or computer instructions) can determine which tasks can be done in accordance with the method according to the present description. In some embodiments, the program is a computer-readable software. The computer includes a code to generate and memorize information and data introduced or generated during the course of the method according to the present description.

[0053] In other possible embodiments, combinable with all the embodiments described here, the signal processing and control unit 26 can be configured to perform the analysis and processing of the signal of the method according to the present description partly by means of software, on a programmable platform, and partly by means of hardware, with discreet electronic devices. Examples of a programmable platform are an electronic device with field programmable logic, known in the field as FPGA (Field Programmable Gate Array), or a digital signal processor, also known in the field as DSP (Digital Signal Processor).

[0054] In possible embodiments, combinable with all the embodiments described here, the sensor element 22 can be configured to be associated with the flowmeter 15, in particular with the turbine 16 so as to collaborate in generating a signal to be sent to the signal converter device 24.

[0055] According to variant embodiments, the sensor element 22 can be a coil for example, or electric coil (inductance). The coil of the sensor element 22 can be excited by a current sent by the signal converter device 24. In this way, the sensor element 22 is suitable to generate a magnetic field. The turbine 16 is positioned in proximity to the sensor element 22, and in this way is immersed in the magnetic field induced by the coil. The turbine 16 is suitable to be made to rotate by the flow of liquid which hits it and, being coated with a conductive coating material, behaves like a conductor body immersed in a magnetic field, thus generating eddy currents in the coating of the turbine 16. In this way, a signal can be generated, based on the position of the turbine 16, which signal can be sent to the signal converter device 24.

[0056] In particular, since it is coated with conductive material, the turbine 16 can be considered an inductance in series with a resistance, therefore from the coupling of the inductance of the sensor element 22 and the turbine 16 a device equivalent to a transformer is defined.

[0057] The entity of the coupling depends on the reciprocal distance between the sensor element 22, which can advantageously be kept fixed, and the turbine 16, on the geometric characteristics and on the form of the conductive coating. Due to the continuous modification of the reciprocal distance between these elements, essentially due to the rotation of the turbine 16 during functioning, the value of inductance of the coil of the sensor element 22 is increased or decreased by a variable inductance value, based on the distance. By detecting these variations it is possible to obtain a signal to be sent to the signal converter device 24 and to the signal processing and control unit 26.

[0058] Advantageously, in order to reduce energy consumption caused by a variable magnetic field generated only by an inductance, it is possible to add a capacitor in parallel to the coil of the sensor element 22. Preferably the capacitor is of a value suitable to make the LC (inductance-capacity) circuit resonate, in order to save energy.

[0059] According to variant embodiments, the signal converter device 24 can act as a proximity sensor. Furthermore, the signal converter device 24 can be configured to have a programmable hysteresis.

[0060] According to variant embodiments, the signal converter device 24 can be an LDC (Inductance to Digital Converter) device, configured to measure the impedance and resonance frequency of the resonator circuit LC.

[0061] According to possible variant embodiments, the signal converter device 24 is configured to generate a signal with a frequency that depends on the relative position of the turbine 16 and the sensor element 22. The frequency also depends on the speed of rotation of the turbine 16 and hence on the flow of liquid.

[0062] One example, not restrictive of the field of protection of the present invention, of a possible signal converter device 24 can be the integrated circuit LDC1000, available on the market from Texas Instruments.

[0063] For the correct functioning of the rapid heating apparatus 10, it is better if the coating on the turbine 16 is kept integral, without wear, cuts or lacerations, otherwise there could be anomalies in the detection of the flow of liquid.

[0064] Usually, the signal is monitored at exit from the sensor element 22, analyzing the development over time and, from this analysis, taking the necessary information on the functioning of the rapid heating apparatus 10. Advantageously, it is detected if there are unexpected variations in the signal to understand if there are cuts, lacerations or worn or consumed parts on the conductive coating material on the turbine 16, since these situations could cause a different flow of liquid to be measured, even greatly different, compared with the real flow, and thus understand that the rapid heating apparatus is working abnormally.

[0065] For example, in the case of a worn turbine 16, a flow of liquid could be detected that is less than that really passing through the rapid heating apparatus 10. In some cases, the flow of liquid measured could be half the actual flow, for example.

[0066] According to variant embodiments described using figs. 1, 2 and 3, the signal converter device 24 can be configured to detect an input signal that represents the proximity signal 34, and the respective wave form that describes it, cited above with reference to the embodiments of the method according to the present description. Furthermore, the signal converter device 24 can be configured to generate an output signal 36.

[0067] In possible implementations, the input signal that represents the proximity signal 34 can be sent from the sensor element 22 to the signal converter device 24 and, after a suitable transformation, the output signal 36 can be sent from the signal converter device 24 to the signal processing and control unit 26.

[0068] According to variant embodiments described using fig. 2, the signal converter device 24 can comprise an inductance-digital converter 46, a feed module 48, a threshold detector 50, a module to register the proximity data 52, a module to register the data of the frequency meter 54, a frequency meter 56 and an interface 58. The interface 58 can be, for example but not restrictively, a serial interface.

[0069] In possible implementations, the inductance-digital converter 46 is configured to detect the proximity signal 34 supplied by the sensor element 22 and make it subsequently processable. The proximity signal 34 detected by the inductance-digital converter 46 can be processed by the threshold detector 50 on the basis of the lower 42 and upper 44 thresholds, to transform it into an output signal 36 with a square wave for example. In particular, it is possible to program the threshold detector 50 to compare the proximity signal 34 with a desired hysteresis. The generation of the square wave form makes the signal more manageable, which for example can be advantageously used for commutation operations, such as for example operations to command a regulation of a functioning parameter, such as for example the temperature of the hot water produced by the apparatus 10.

[0070] According to possible embodiments, the proximity signal 34 can be transformed into the output signal 36 by carrying out the following operations:

- setting a suitable lower threshold 42 and a suitable upper threshold 44 comprised between the minimum value and the maximum value of the proximity signal 34, wherein a suitable value is attributed to the upper threshold 44, greater than that of the lower threshold 42;
- detecting by means of the threshold detector 50 when the proximity signal 34 increases above the value of the upper threshold 44 and detecting when the proximity signal 34 decreases below the value of the lower threshold 42;
- generating an output signal 36 based on the data detected by the threshold detector 50.

[0071] According to variant embodiments described using fig. 3, the output signal 36 can be for example a square wave with a frequency depending on the speed of rotation of the turbine 16, on the number of blades 17 and therefore corresponding to a determinate flow of liquid.

[0072] According to some variant embodiments, the frequency of the output signal 36 can be the same as the proximity signal 34.

[0073] According to variant embodiments, the wave form of the output signal 36 can be defined as "high" from the moment when the proximity signal 34 at entrance rises above the value of the upper threshold 44, while it can be defined as "low" from the moment the proximity signal 34 goes below the value of the lower threshold 42, or vice versa.

[0074] The values of the lower threshold 42 and the upper threshold 44 influence the duty cycle of the output signal 36.

[0075] Furthermore, these values can influence the quality of the output signal 36. In possible implementations, the module to register the proximity data 52 is configured to memorize suitable data of the proximity signal 34, collaborating in timing with the frequency meter 56 and the module to register the data of the frequency meter 54.

[0076] In possible implementations, the interface 58 can be configured to receive the data processed and make the output signal 36 available. The output signal 36 can be further processed by the signal processing and control unit 26.

[0077] In possible implementations, the feed module 48 can be configured to receive the necessary power to feed and make at least the signal converter device 24 function.

[0078] The signal processing and control unit 26 is configured to be associated at least with the signal converter device 24 and the rapid heating unit 18.

[0079] The output signal 36 can be sent to the signal processing and control unit 26, which depending on this signal manages the rapid heating unit 18, for example.

[0080] According to possible embodiments, the signal converter device 24 can include the signal processing and control unit 26.

[0081] Furthermore, the signal processing and control unit 26 is configured to be connected also to the sensor element 22.

[0082] The proximity signal 34 can be sent not only to the signal converter device 24 but also to the signal processing and control unit 26, to be processed.

[0083] According to some embodiments, the detection and control device 20 can comprise a user interface 33 configured to allow a user to send a signal to regulate the temperature of the liquid to the rapid heating unit 18. By way of example, the user interface 33 can comprise, in particular, buttons and/or keys (not shown), which allow to set at least an increase or a decrease in the value of the temperature of the liquid.

[0084] According to other variant embodiments, the user interface 33 can allow to set a desired exit temperature of the liquid from the rapid heating apparatus 10.

[0085] When a user regulates the temperature by means of the user interface 33, the signal processing and control unit 26 detects the value set. Based on this, and at least on the output signal 36, the signal processing and control unit 26 is configured to signal to the rapid heating unit 18 the entity of the increase or decrease in heat energy required to be supplied to the liquid.

[0086] This signal to the rapid heating unit 18 can be carried out for example by varying the duty cycle and/or frequency of the signal sent.

[0087] It is preferable if the input signal that represents the proximity signal 34 sent by the sensor element 22 to the signal converter device 24 is an "ideal" signal, such as a regular wave that has a succession of peaks with maximum primary points 38 all of the same value and equidistant from each other. By "ideal" signal we mean a signal characterized by a wave form of a given period that is repeated exactly the same, given the same flow of liquid, and is noiseless and/or without distortions. This wave could easily be processed by the signal converter device 24 without any possibility of errors in detection. However, as will be explained in more detail hereafter, this does not occur in practice. For example, in practice, the frequency at which the maximum primary points 38 are repeated can typically depend on the speed of rotation of the turbine 16 and/or on the number of blades 17 of the turbine 16. As described in detail hereafter, Applicant has found in experiments that the proximity signal 34, in real conditions, could have a succession of peaks with maximum primary points, some of which, for example alternately, have different values from each other, that is, a divergence from ideal conditions can have the effect of modifying some peaks, generating a succession of high peaks and low peaks, as defined hereafter.

[0088] In practice, as described using figs. 1 and 4, the proximity signal 34 detected by the sensor element 22 and sent to the signal converter device 24, when the turbine 16 is integral, is not "ideal" but has a wave form that is not constant and not clean, having maximum secondary points 40, associated with the low peaks, as well as the maximum primary points 38 associated with the high peaks.

[0089] Applicant has found in experiments that all these maximum secondary points 40 that occur in practice in the proximity signal 34 have values lower than the minimum value of the maximum primary points 38.

[0090] Preferably, to correctly process the proximity signal 34, Applicant has found that it is better if the value of the maximum secondary points 40 is lower than the value set for the lower threshold 42, and that the value of the maximum primary points 38 is greater than the value set for the higher threshold 44.

[0091] Typically, when the turbine 16 is integral, the number of maximum primary points 38 and the number of maximum secondary points 40, that is to say, the number of high peaks and the number of low peaks, are in a defined numerical ratio with each other, for example, as described using fig. 4, the number of maximum primary points 38 and the number of maximum secondary points 40 could be in a ratio of 1:1.

[0092] Applicant has found in experiments that, when the coating of the turbine 16 is damaged and/or cut, analyzing a period T or a whole multiple of periods of the proximity signal 34, the number of maximum secondary points 40, that is, of low peaks, is higher than the number of maximum primary points 38, that is, of high peaks, as shown for example in fig. 5.

[0093] Furthermore, Applicant has also found in experiments that, when the coating of the turbine 16 is damaged and/or cut, the number of maximum secondary points 40, that is, of low peaks, is higher, given the same other conditions, than the number of maximum secondary points 40 that are identified when the turbine 16 is integral.

[0094] According to one aspect of the present invention, it is possible to detect the malfunctioning of the flowmeter 15 due for example to damage of the coating of the turbine 16, by analyzing the proximity signal 34 received from the signal converter device 24.

[0095] The proximity signal 34 can be analyzed for example by the signal processing and control unit 26, comparing the number of maximum secondary points 40, or low peaks, with the number of maximum primary points 38, or high peaks.

[0096] If a number of maximum secondary points 40, or low peaks, is detected, higher than the number of maximum primary points 38, or high peaks, this means that the flowmeter 15 is measuring the flow of liquid erroneously, reporting a wrong value and hence potentially dangerous.

[0097] According to possible implementations, it can be provided to pre-set a margin of tolerance inside which to evaluate by how much the number of maximum secondary points 40 or low peaks is higher than the number of maximum primary points 38.

[0098] The pre-set margin of tolerance can depend for example on the specific proximity signal 34 produced by different turbines 16 and detected by the sensor element 22.

[0099] For example, in some cases the proximity signal 34 could be produced by a damaged and/or cut and/or worn turbine 16, and then there could be an above normal ratio between the number of maximum secondary points 40, or low peaks, and the number of maximum primary points 38, or high peaks: as we explained above, this is an indication of malfunctioning or damage of the turbine 16. Furthermore, this above normal ratio can lead to a variation in the frequency of the output signal 36. For example, in this case, the variation in frequency of the output signal 36 can correspond to a reduction, for example by half. If this variation were not interpreted correctly, and were associated with a hypothetical variation in the flow and not, in reality, with a malfunction or damage of the turbine 16, then the temperature control would also be wrong.

[0100] According to possible embodiments, combinable with all the embodiments described here, the control method can therefore provide:

- to sample the proximity signal 34 with a suitable sampling frequency which can be correlated to said period T;
- setting the upper threshold 44 with a higher value than the lower threshold 42 by an adequate quantity;
- detecting as maximum primary points 38, or high peaks, the relative maximums of the wave every time the upper threshold 44 is exceeded, and as maximum secondary points 40, or low peaks, the relative maximums of the wave when this goes below the lower threshold 42, based on a period of the proximity signal 34 or a whole multiple thereof;
- comparing the number of maximum secondary points 40, or low peaks, with the number of maximum primary points 38, or high peaks;
- generating a signal of possible malfunction or damage of the turbine 16, and hence the flowmeter 15, when the number of maximum secondary points 40, or low peaks, is higher than the number of maximum primary points 38, or high peaks, by a certain margin of tolerance.

[0101] Some embodiments can provide the execution of various steps, passages and operations, as described above. The steps, passages and operations can be done with instructions performed by a machine which cause the execution of certain steps by a general-purpose or special-purpose processor. Alternatively, these steps, passages and operations can be performed by specific hardware components that contain hardware logic to perform the steps, or by any combination of components for programmed computers and personalized hardware components.

[0102] Embodiments of the method in accordance with the present description can be included in a program for computers that can be memorized in a computer-readable mean that includes the instructions that, once performed by a rapid heating apparatus 10, determine the execution of the method discussed here.

[0103] In particular, elements according to the present invention can be given as machine-readable means to memorize the instructions which can be carried out by the machine. The machine-readable means can include, without being limited to, floppy disks, optical disks, CD-ROM, optical-magnetic disks, ROM, RAM, EPROM, EEPROM, optical or magnetic cards, propagation means or other types of machine-readable means suitable to memorize electronic information. For example, at least parts of the present invention can be downloaded as a computer program that can be transferred from a remote computer (for example a server) to a requesting computer (for example a client), by means of data signals received with carrier waves or other propagation means, via a communication connection (for example a modem or a network connection).

[0104] By analyzing the number of high peaks (above a certain threshold) and low peaks (below a certain threshold) detected in a certain period of time and evaluating if the difference between the number of low peaks and high peaks is higher than a predefined value, plus a possible margin of tolerance, the embodiments described here allow to detect the malfunctioning or damage of the rotor of the turbine. It is therefore possible to detect the malfunctioning or damage of the rotor of the turbine 16 based on conditions detected in the specific functioning environment, where by environment we mean the whole chain, including for example also the signal converter device 24, which leads to the generation of the proximity signal 34 analyzed.

[0105] The embodiments described here therefore achieve the set purposes of obtaining a control method for a rapid heating apparatus for liquids and a corresponding rapid heating apparatus for liquids that implements the method, which are usable to detect the flow of liquid in cooperation with a flowmeter and to recognize possible malfunctions or damage of the rotor of the turbine provided in the flowmeter, simply, practically and precisely. Furthermore, a rapid heating apparatus for liquids is obtained that is long-lasting, reliable and economical.

[0106] It is clear that modifications and/or additions of parts may be made to the control method and the rapid heating apparatus 10 for liquids as described heretofore, without departing from the field and scope of the present invention.

[0107] It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve many other equivalent forms of control method and rapid heating apparatus 10 for liquids, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

[0108] In the following claims, the sole purpose of the references in brackets is to facilitate reading: they must not be considered as restrictive factors with regard to the field of protection claimed in the specific claims.

Claims

1. Control method for a rapid heating apparatus (10) for liquids, **characterized in that** said control method comprises:

    - detecting, using a detection and control device (20), a proximity signal (34) correlated to a flowmeter (15) able to measure a flow of liquid in a rapid heating unit (18) of the rapid heating apparatus (10), and provided with a turbine (16) with a rotor, wherein said proximity signal (34) is a signal generated by the cooperation of proximity between a sensor element (22) and the turbine (16) of said flowmeter (15);
    - analyzing a temporal development of the proximity wave form of the proximity signal (34);
    - defining a lower threshold (42) and an upper threshold (44) in the temporal development of said proximity wave form;
    - defining, in the temporal development of said proximity wave form, as a low peak a peak whose maximum is below the lower threshold (42) and as a high peak a peak whose maximum is above the upper threshold (44);
    - detecting and counting the number of high peaks and the number of low peaks inside a period (T), or a whole multiple of said period (T), of the temporal development of the proximity wave form of the proximity signal (34);
    - if the number of low peaks in the period (T) is greater, possibly by a defined margin of tolerance, than the number of high peaks, supplying an indication of malfunctioning or damage of the rotor of the turbine (16) of the flowmeter (15).

2. Method as in claim 1, **characterized in that** analyzing said proximity signal (34) provides to sample said proximity signal (34) with an adequate sampling frequency.

3. Method as in claim 1 or 2, **characterized in that** defining the low peaks and the high peaks provides to detect the points of relative maximum of the proximity signal (34) and to recognize, among said points of relative maximum, primary points of maximum (38) as the relative maximums of the proximity signal (34) each time said upper threshold (44) is exceeded, associating them with said high peaks, and secondary points of maximum (40) as the relative maximums of the proximity signal (34) when this falls below said lower threshold (42), associating them with said low peaks.

4. Method as in claim 1, 2 or 3, **characterized in that** the generation of the proximity signal (34) occurs by exciting a coil of said sensor element (22), producing a magnetic field that induces eddy currents in a conductive coating of said turbine (16) and detecting the variations of the eddy currents due to the rotation of said turbine (16).

5. Method as in any claim hereinbefore, **characterized in that** defining the lower threshold (42) and the upper threshold (44) comprises processing said proximity signal (34), setting said lower threshold (42) and said upper threshold (44) comprised between the minimum value and the maximum value of the proximity signal (34), wherein a suitable value is attributed to said upper threshold (44), greater than that of said lower threshold (42).

6. Method as in any claim hereinbefore, **characterized in that** it provides to detect when the proximity signal (34) increases above the value of said upper threshold (44) and when it decreases below the value of said lower threshold (42), and to generate a correlated output signal (36) in the form of a square wave.

7. Method as in any claim hereinbefore, **characterized in that,** as a function of the indication of malfunctioning or damage of the flowmeter (15), it comprises supplying an alarm signal, or adjusting or interrupting the functioning of said heating unit (18).

8. Rapid heating apparatus for liquids, **characterized in that** said rapid heating apparatus for liquids comprises:

    - a rapid heating unit (18),
    - a flowmeter (15) able to measure a flow of liquid in the rapid heating unit (18) and provided with a turbine (16) with a rotor;
    - a detection and control device (20) comprising at least a sensor element (22) configured to cooperate in proximity with the turbine (16) of the flowmeter (15) in order to generate a proximity signal (34), said detection and control device (20) being configured to:
    - detect the proximity signal (34) correlated to said flowmeter (15) with respect to said detection and control device (20),
    - analyze a temporal development of the proximity wave form of the proximity signal (34),
    - detect and count inside a period (T), or a whole multiple of said period (T), of the temporal development of the proximity wave form of said

proximity signal (34), the number of high peaks and the number of low peaks, where in the temporal development of said proximity wave form a peak whose maximum is below a lower threshold (42) is defined as a low peak, and a peak whose maximum is above an upper threshold (44) is defined as a high peak, wherein said lower threshold (42) and said upper threshold (44) are defined in the temporal development of said proximity wave form;
- supply an indication of malfunction or damage of the rotor of the turbine (16) of the flowmeter (15), if the number of low peaks in the period (T) considered is greater, possibly by a defined margin of tolerance, than the number of high peaks.

9. Apparatus as in claim 8, **characterized in that** said turbine (16) is coated with a conductive material and said detection and control device (20) comprises at least a sensor element (22) configured to cooperate with said turbine (16) so as to generate said proximity signal (34), at least a signal converter device (24) and at least a signal processing and control unit (26).

10. Computer program memorizable in a computer-readable mean that contains the instructions which, once carried out by an apparatus as in claim 8 or 9, determine the execution of the method as in any of the claims from 1 to 7.

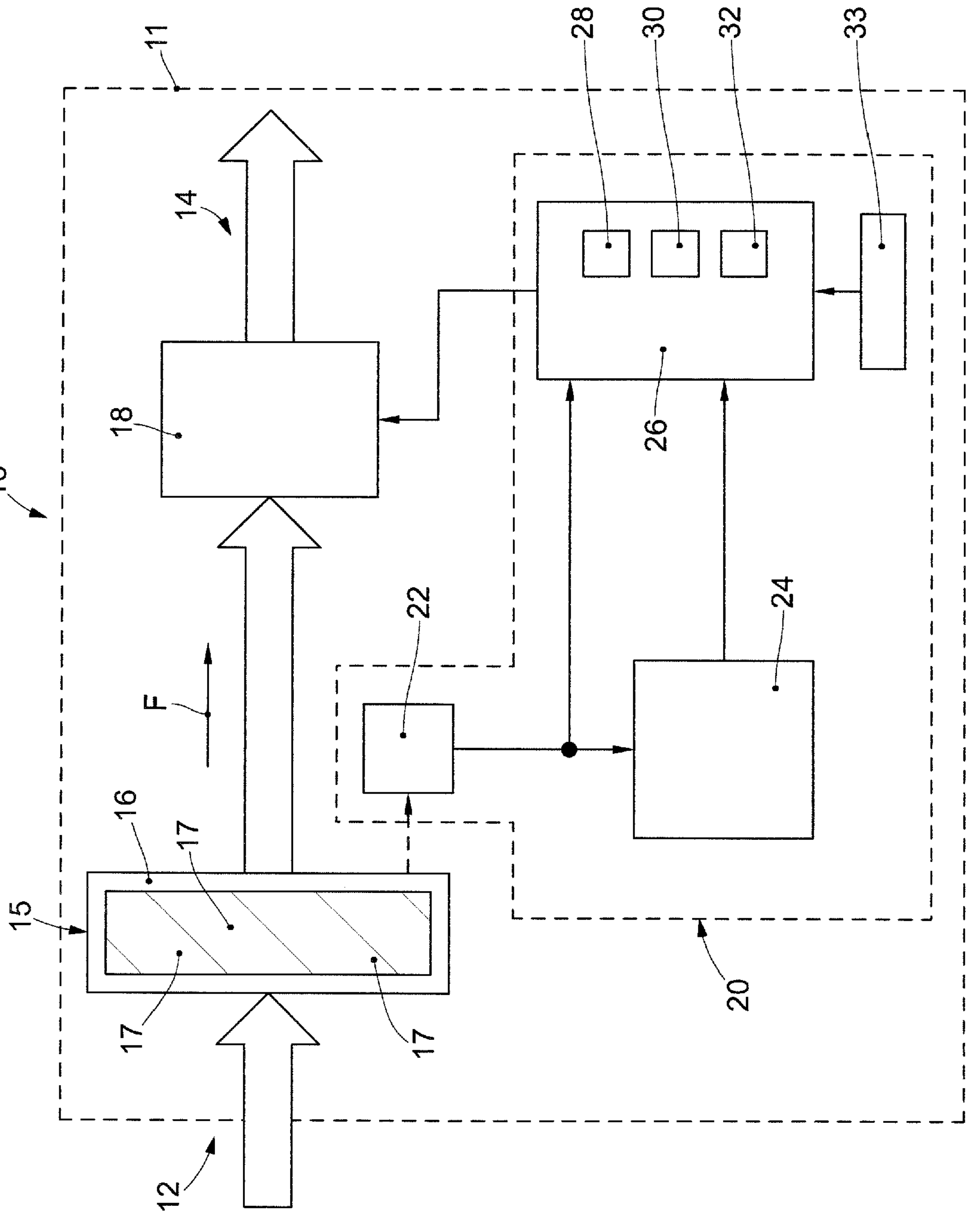

fig. 1

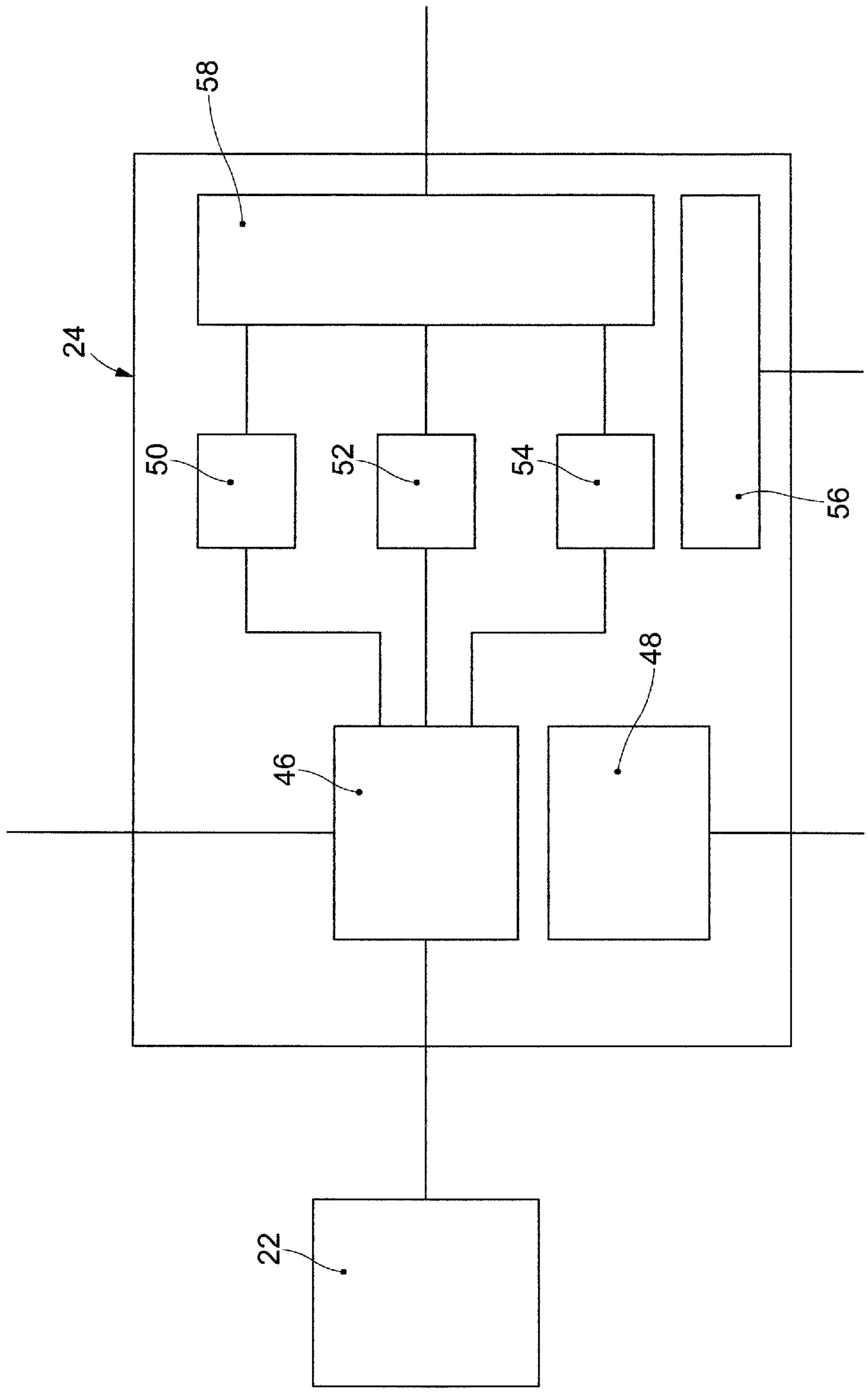

fig. 2

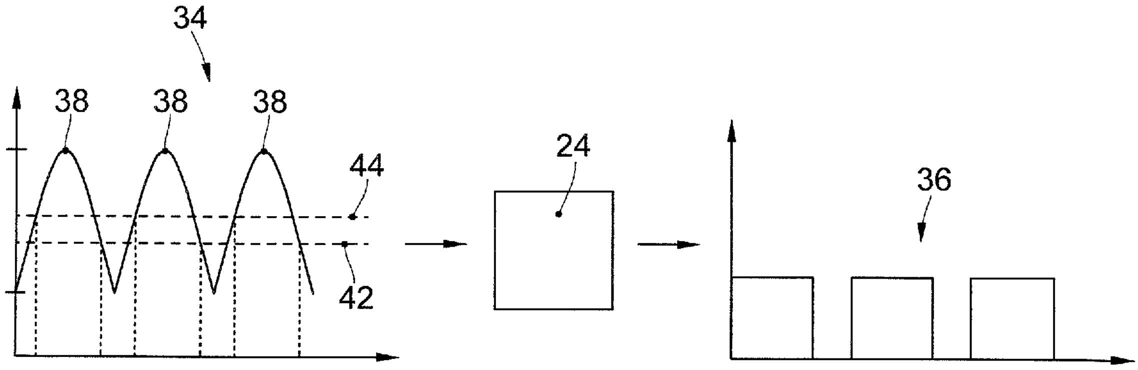

fig. 3

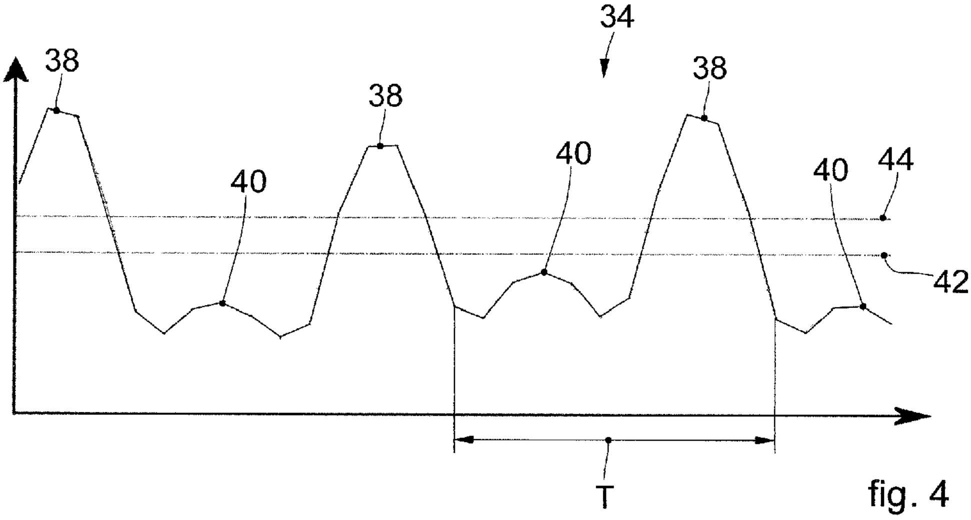

fig. 4

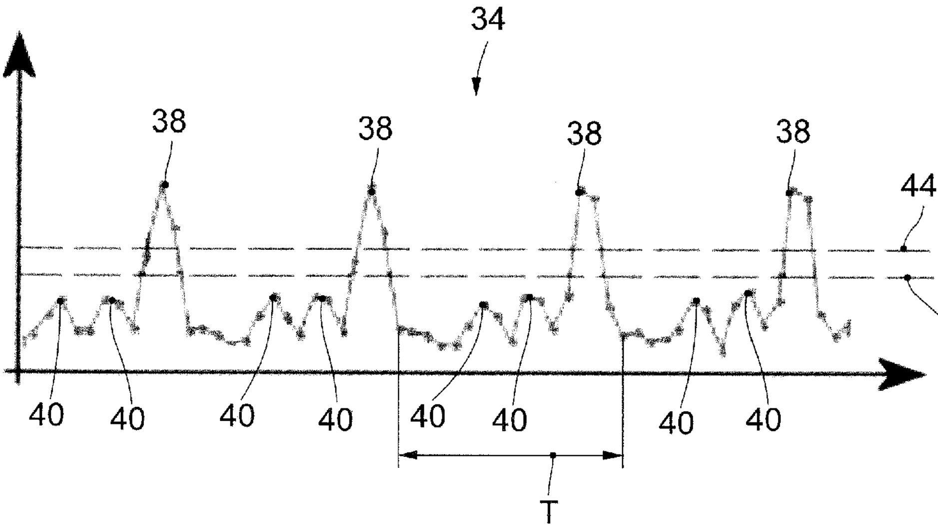

fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 16 18 8206

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2

Place of search	Date of completion of the search	Examiner
Munich	24 January 2017	Riesen, Jörg

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