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(54) **A METHOD FOR DETECTING AIR IN A HEATING OR COOLING SYSTEM, AND A HEATING OR COOLING SYSTEM**

(57) An air detection process (15) for detecting air in a heating or cooling system (1) comprises one or more air detection steps (15.1, ..., 15.n) wherein, with a circulation pump (5) activated (F1) at a circulation speed, detecting a parameter (x) indicative of the water flow rate inside a hydraulic circuit (2) (F2), collecting a plurality of values (x_t) of the parameter (x) detected in a detection time interval (F3), calculating a variation (FlowRate_StdDev) of the plurality of values (x_t) collected in the detection time interval (F4), comparing the calculated variation (FlowRate_StdDev) with a variation threshold value (Threshold_var) (F5), and if the calculated variation (FlowRate_StdDev) is greater than the variation threshold value (Threshold_var), generating an notification signal of air presence in the hydraulic circuit (2) (F6).

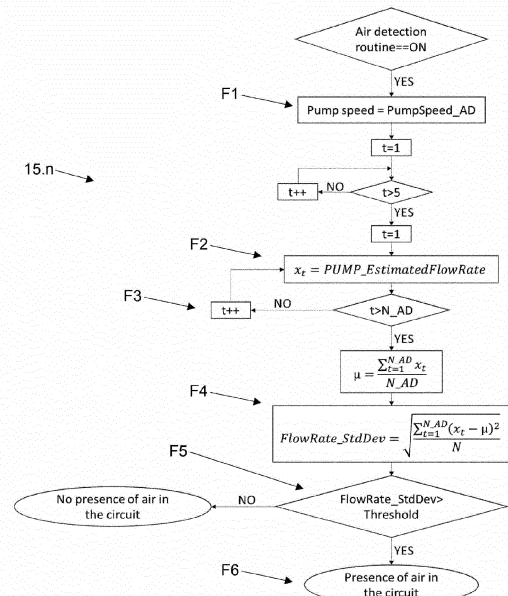


FIG. 8

Description

[0001] Heating systems for supplying radiators or similar heating devices with hot water comprise a heat generator, typically consisting of a gas boiler or a heat pump, connected to a hydraulic circuit along which heating devices are provided, installed in various rooms of the house, e.g., wall radiators or under-floor exchangers.

[0002] The heating system heats the water and conveys it through the heating devices by means of which the heat of the water is transferred to the environment. The water is heated to a working temperature, by means of the heat generator placed in a heat exchange relationship with the hydraulic circuit, where a system for controlling the heat generator controls the activation, shutdown, and power adjustment of the heat generator, e.g., of a burner of a gas boiler or a compressor of a heat pump, as well as the activation, shutdown, and flow rate adjustment of a water circulation pump, for example for varying the flow of water conveyed through the hydraulic heating circuit.

[0003] The control system controls the operation of the heat generator and the circulation pump as a function of one or more temperature values selectable by a user and detected values of the ambient temperature in the environments to be heated and the temperature of the water in the hydraulic heating circuit.

EP2918923A1 describes a heating system according to the prior art and having features of the preamble of claim 1. EP1593916B1 and KR20040081983A describe systems of the prior art that represent a technological context for the invention.

[0004] One of the commonest problems in domestic heating systems is the presence of air bubbles in the hydraulic circuit, which results in:

- lower system energy efficiency,
- non-uniform temperatures in hydraulic circuit and heating devices (hotter and colder zones),
- noisy water circulation and circulation pump,
- anomalous operation of the heat generator, as the air bubbles cause circulation vacuums of the heat-transfer fluid, which can lead to overheating of the heat generator, resulting in damages.

[0005] In these anomalous operating conditions, the heat generator, e.g., a gas boiler, initiates safety procedures aimed at protecting the reliability thereof over time, which can result in undesired temporary or permanent operating blocks.

[0006] For these reasons, during the installation and/or extraordinary maintenance of the heating system, it is necessary and known to thoroughly de-aerate the whole heating system and the heat generator in order to ensure the optimum operation thereof.

[0007] It is also known that after completely bleeding the heating system of air, a little air tends to go back to the hydraulic circuit over time (e.g., due to leaks), which is why it is necessary to repeat the de-aeration operation periodically.

[0008] It is known to bleed the heating system of air by means of:

- a so-called de-aerator, i.e., a valve positioned in the hydraulic circuit or heat generator, manually operable for letting out residual air, and/or
- an automatic vent valve, which can be positioned in the hydraulic circuit and/or heat generator (boiler) and which performs an automatic bleeding of the air without manual intervention.

[0009] Typically, the de-aeration valves of the heating system are only opened by a skilled operator (technical service centers) and only during in-situ interventions, to avoid undesired side effects (which are difficult to manage for unskilled users) during the service life of the heating system.

[0010] Some known boilers also comprise an electronic control function for bleeding the air in both the local circuit of the boiler and the hydraulic circuit of the central heating system, which performs specific control sequences of controlling the circulation pump and a diverter valve for diverting the heat transfer fluid between the primary circuit of the boiler and the hydraulic heating circuit so as to carry the air bubbles of both circuits into the de-aerator.

[0011] This function is also generally manually activated by a skilled operator.

[0012] The air bleeding is typically carried out by skilled operators during installation or extraordinary maintenance and takes a long time, because there is no indicator of the presence of air and the only known clues for understanding whether the air has been completely bled are the circulation noises and operating anomalies of the boiler (e.g., overheating).

[0013] Similarly, the same problems arise for cooling systems and for heating and cooling systems with a hydraulic circuit.

[0014] Therefore, it is the object of the present invention to provide a method for verifying the presence of air in the heating and/or cooling system, having features such as to obviate at least some of the drawbacks of the prior art.

[0015] Within the scope of the main object, it is a particular object of the invention to provide a method which provides

a more objective indicator of the presence of air in the central heating and/or cooling system.

[0016] These and other objects are achieved by a process according to claim 18, and by a heating and/or cooling system according to claim 1.

[0017] The dependent claims relate to advantageous and preferred embodiments.

[0018] According to one aspect of the invention, there is provided a method for detecting air in a heating or cooling system, in particular a domestic system, of the type comprising:

a hydraulic circuit along which heating/cooling devices are installed, e.g., wall radiators or under-floor exchangers, a heat/cold generator, e.g., a gas boiler or a heat pump, placed in a heat exchange relationship with the hydraulic circuit,

a water circulation pump, installed in the hydraulic circuit, to convey a flow of water into the hydraulic circuit, an electronic control system in signal connection with the heat/cold generator and the circulation pump, to control the operation of the heat/cold generator and the circulation pump, wherein the method comprises the steps of:

- with the circulation pump activated, detecting a parameter indicative of the water flow rate inside the hydraulic circuit,
- collecting a plurality of values of the parameter detected in a detection time interval,
- calculating a variation of the plurality of values collected in the detection time interval,
- comparing the calculated variation with a variation threshold value, and:

if the calculated variation is greater than the variation threshold value, generating a notification signal of air presence in the hydraulic circuit, and

if the calculated variation is lower than the variation threshold value, not generating the notification signal of air presence in the hydraulic circuit.

[0019] Similarly, according to an aspect of the invention, a heating or cooling system (e.g., a boiler or a heat pump system), in particular a domestic system, comprises:

a heat or cold generator, e.g., a gas boiler or a heat pump, connectable in a heat exchange relationship to a hydraulic circuit along which heating or cooling devices are installed, e.g., wall radiators or underfloor exchangers, a water circulation pump, connectable to the hydraulic circuit, to convey a flow of water into the hydraulic circuit, an electronic control system in signal connection with the heat/cold generator and the circulation pump, to control the operation of the heat or cold generator and the circulation pump, comprising an air detection module configured to perform an air detection process 15, comprising one or more air detection steps 15.1, ..., 15.n where:

- with the circulation pump activated, it detects a parameter indicative of the water flow rate inside the hydraulic circuit,
- it collects a plurality of values of the parameter detected in a detection time interval,
- it calculates a variation of the plurality of values collected in the detection time interval,
- it compares the calculated variation with a variation threshold value, and:

if the calculated variation is greater than the variation threshold value, it generates notification signal of air presence in the hydraulic circuit, and

if the calculated variation is lower than the variation threshold value, it does not generate the notification signal of air presence in the hydraulic circuit.

[0020] By virtue of the correlation between the presence of air in the hydraulic circuit and the oscillation of the water flow rate, there is a more objective parameter for determining the presence of air in the hydraulic circuit. In fact, the greater the amount of air trapped inside the hydraulic circuit, the more the water flow speed and rate varies with the same (constant) operation of the circulation pump during the detection interval. In fact, the inventors have understood that the circulation vacuums produced by the air bubbles can be detected through a variation model of a signal linked to the water circulation.

[0021] The variation measurement of the flow rate or speed, detected directly or by means of the detection of flow parameters or related electrical parameters, provides an easily obtainable determination criterion, which is electronically processable and reliable.

[0022] Further advantageous aspects of the invention will become apparent from the following description of some

embodiments thereof, given by way of non-limiting example, with reference to the accompanying drawings, in which:

- figure 1 is a diagrammatic view of a heating and/or cooling system according to an embodiment of the invention,
- figures 2, 3, 4, 5 are diagrammatic views of heating and/or cooling systems according to embodiments, in which:
- in figure 2, a flow rate detector is integrated into a circulation pump inside the housing of a heat or cold generator,
- in figure 3, a flow rate detector is integrated into a circulation pump installed in a hydraulic circuit outside the housing of the heat or cold generator,
- in figure 4, a flow rate detector is installed in a hydraulic circuit outside the housing of the heat or cold generator, irrespective of the circulation pump,
- in figure 5, a flow rate detector is installed in a hydraulic circuit inside the housing of the heat or cold generator, irrespective of the circulation pump,
- figure 6 is a diagram showing the trend of the flow rate (ordinate) detected in a hydraulic circuit, as a function of the time (abscissa), in a plurality of detection cycle steps, where each detection cycle comprises a plurality of detection steps at different pump circulation speeds, and where a progressive reduction of the variation of the flow rate can be seen with an increase in the number of detection and de-aeration cycles,
- figure 7 is a diagram showing, for the situation illustrated in figure 6, the trend of the standard deviation of the flow rate (ordinate) detected in the hydraulic circuit, as a function of the time (abscissa) for a pump speed set at 60% of a maximum speed, in the detection cycles from 1 to 5,
- figure 8 shows a flow diagram of the air detection method according to an embodiment,
- figure 9 shows a flow diagram of the air detection method according to a further embodiment.

[0023] With reference to the figures, a heating or cooling system 1 (e.g., a gas boiler or a heat pump system), in particular a domestic system, comprises:

a heat or cold generator 4, e.g., a gas boiler or a heat pump, connectable in a heat exchange relationship to a hydraulic circuit 2 along which heating and/or cooling devices 3 can be installed, e.g., wall radiators or underfloor exchangers,

a water circulation pump 5, connectable to the hydraulic circuit 2, to convey a flow of water into the hydraulic circuit 2, an electronic control system 6 in signal connection with the heat or cold generator 4 and the circulation pump 5, to control the operation of the heat or cold generator 4 and the circulation pump 5,

an air detection module 7, 7' configured so as to perform an air detection process 15, comprising one or more air detection steps 15.1, ..., 15.n, where:

- with the circulation pump 5 activated (step F1) at a circulation speed, it detects a parameter x indicative of the water flow rate inside the hydraulic circuit 2 (step F2),
- it collects a plurality of values x_t of the parameter x detected in a detection time interval (step F3),
- it calculates a variation FlowRate_StdDev of the plurality of values x_t collected in the detection time interval (step F4),
- it compares the calculated variation FlowRate_StdDev with a variation threshold value Threshold_var (step F5) and:

[0024] if the calculated variation FlowRate_StdDev is greater than the variation threshold value Threshold_var, it generates a notification signal of air presence in the hydraulic circuit 2 (step F6), and

[0025] if the calculated variation FlowRate_StdDev is lower than the variation threshold value Threshold_var, it does not generate the notification signal of air presence in the hydraulic circuit.

[0026] According to an advantageous embodiment, the air detection module 7, 7' is configured so that, if during a first air detection step 15.1 of the air detection steps 15.1, ..., 15.n, with a first pumping speed of the circulation pump 5, the calculated variation FlowRate_StdDev is lower than the variation threshold value Threshold_var, the air detection module 7, 7' performs a further subsequent air detection step 15.2, with a further pumping speed of the circulation pump 5, which is different from the first pumping speed.

[0027] In fact, as can be seen in figures 6 and 7, which will be described in detail below, the calculated variation FlowRate_StdDev may differ significantly as a function of the flow speed. Therefore, performing the air detection process 15 by means of a plurality of air detection steps 15.1, ..., 15.n at different flow speeds of the circulation pump 5, significantly increases the reliability and result precision thereof.

[0028] According to an embodiment, the air detection process 5 and the air detection module 7, 7' perform the first air detection step 15.1 with a first pumping speed and the subsequent air detection step(s) 15.2, ..., 15.n with pumping speeds decreasing from one air detection step 15.n-1 to the subsequent air detection step 15.n (figure 6), for example in the order of number of the air detection step 15.1, ..., 15.4, the pumping speed is 100%, 80%, 60%, 40% of the

maximum speed of pump 5.

[0029] The pumping speed of the circulation pump 5 is preferably constant within the same air detection step 15.n.

[0030] The duration of the detection interval is preferably constant, e.g., 25 seconds or in the range from 20 seconds to 30 seconds.

[0031] The number of values x detected and collected during the detection interval is preferably constant, e.g., 25 or in the range from 20 to 30, detected with a detection frequency of 1 value/second, for example.

[0032] The variation threshold value Threshold_var is preferably different for different pumping speeds of the circulation pump 5.

Description of further embodiments

[0033] According to an embodiment, when determining the presence of air in the hydraulic circuit 2, i.e., if the calculated variation FlowRate_StdDev is greater than the variation threshold value Threshold_var, the (reception of the) notification signal of air presence in the hydraulic circuit 2 can form the base for, or trigger subsequent method steps, e.g., one or more visual and/or acoustic notification steps and/or one or more anomaly control steps of the heat or cold generator 4 and/or the circulation pump 5, and/or a safety shutdown step of the heat or cold generator 4 and the circulation pump 5.

[0034] The visual and/or acoustic notification can occur by means of a user interface 12 of the electronic control system 6 of the heating or cooling system 1, positioned directly on board the heat or cold generator 4 or externally thereto, for example, or by means of a further user interface 12' of an air detection module 7' outside the electronic control system 6 of the heating or cooling system 1.

[0035] According to embodiments, the air detection module 7, 7' can be an electronic processing module 7 directly integrated into the electronic control system 6 of the heating or cooling system 1 or an electronic processing module 7' outside the latter and temporarily or permanently connectable to the heating or cooling system 1 (signal and/or hydraulic and/or electrical connection) as a retrofitting accessory.

[0036] According to a further embodiment of the method and system 1, in response to the notification signal of air presence an anomaly notification signal is transmitted (step F9), e.g., by cable or wirelessly (from the electronic control system 6 or the air detection module either integrated 7 or external 7', for example) to a remote server 13 (cloud) which, in response to receiving the anomaly notification signal, performs a maintenance preparation procedure (step F10).

[0037] The maintenance preparation procedure F10 can comprise sending an electronic message, e.g., by telephone, SMS, email, etc., to the user or an administrator in charge of the heating or cooling system 1.

[0038] According to an embodiment, the remote server 13:

- collects the anomaly notification signals received from a plurality of said different heating or cooling systems 1, for the entire service life of the systems 1 and keeps the anomaly notification signals stored, even of systems 1 made inoperative,
- correlates the anomaly notification signals of each system 1 with the time,
- identifies progressive increase patterns of the presence of air depending on the operating time for each system 1, as a function of the correlation of the anomaly notification signals with the time,
- compares the progressive increase patterns of the presence of air identified between different systems 1 to estimate, for the operating systems 1, a residual time without the need for de-aeration (predictive maintenance step F11).

[0039] According to an embodiment, the air detection module 7, 7' is configured to (and the air detection method comprises):

- allow the manual insertion of a starting command (step F7) for the air detection process 15, e.g., by means of an operator interface or the aforesaid user interface 12 or by means of the further user interface 12', or by means of a remote electronic device 14, such as the remote server 13, for example, in signal connection with the air detection module 7, 7', and
- in response to the command for starting the air detection process, perform the air detection process 15.

[0040] Alternatively or additionally, the air detection module 7, 7' can be configured to (and the air detection method can comprise) performing the air detection process 15 automatically as a function of a predetermined starting criterion (or set of criteria).

[0041] The starting criterion or set of criteria (and/or the verification F8 thereof) can comprise:

- a predetermined time interval, e.g., every day at a certain time or every 500 or 1000 hours, and/or
- detecting, e.g., by means of the electronic control system 6 or the air detection module 7, 7', a water flow anomaly in the hydraulic circuit 2, e.g., a low flow rate, a low water pressure, or an unstable flow rate, or a noisy flow or

vibrations of the hydraulic circuit 2 and/or the heating or cooling devices 3, and/or

- detecting, e.g., by means of the electronic control system 6 or the air detection module 7, 7', a temperature control anomaly of the heating or cooling system 1.

Detailed description of the detection of parameter x indicative of the flow rate

[0042] According to an embodiment, the parameter x indicative of the flow rate is obtained (e.g., from the air detection module 7) by a flow rate signal provided by the circulation pump 5. To this end, the circulation pump 5 can comprise a flow rate sensor 8 (flowmeter) or an indirect determination device 9 for the flow rate depending on electrical parameters (of the electric motor 10) of the circulation pump 5.

[0043] According to an embodiment, the parameter x indicative of the flow rate is obtained (e.g., from the air detection module 7) by a signal of a flow rate sensor 8 (flowmeter) connected to the hydraulic circuit 2 outside the circulation pump 5, e.g., inside or outside a housing 11 of the heat or cold generator 4. Here, the parameter x indicative of the flow rate is the flow rate itself.

[0044] Alternatively, the parameter x indicative of the flow rate is obtained (e.g., from the air detection module 7) by a prevalence signal generated by the circulation pump 5, or by a signal of electric power (or electric current) absorbed by the electric motor 10 of the circulation pump 5 or by a signal of the number of revolutions or angular speed of the electric motor 10 of the circulation pump 5.

Detailed description of the calculation of the variation FlowRate_StdDev of the plurality of values x_t

[0045] According to a preferred embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating a standard deviation of the plurality of values x_t collected in the detection time interval, e.g., by means of the formula:

$$\text{FlowRate_StdDev} = \sqrt{\frac{\sum_{i=1}^N (x_i - \mu)^2}{N}},$$

where:

$$\mu = \frac{\sum_{i=1}^N x_i}{N},$$

N is the number of collected values x_t,

x_i is the individual value of the parameter x detected or determined or estimated.

[0046] According to an alternative embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating a relative standard deviation or variation coefficient.

[0047] According to a still further embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating an average value of the absolute differences between all values x of the plurality of values x_t and an average value of all values x of the plurality of values x_t.

[0048] According to a still further embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating an average value of the absolute differences between all values x of the plurality of values x_t and a central value (halfway between a maximum value and a minimum value) of all values x of the plurality of values x_t.

[0049] According to a still further embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating a degree of non-cyclicity or a degree of randomness of a sequence (in the order of time) of the values x of the plurality of values x_t. The greater the randomness, the greater the probability that the fluctuation is due to air in the system and not to cyclic pumping phenomena.

[0050] It should be noted that the name FlowRate_StdDev is an invented name which, despite the resemblance, does not necessarily indicate a standard deviation and does not necessarily refer to a flow rate, but to a parameter indicative or representative of the flow rate.

Description of figure 6

[0051] Figure 6 shows the trend of the flow rate with respect to time: during alternate steps of the air detection 15 and de-aeration process of the system 1, starting from a situation with a great amount of air in the system 1 and performing, for each air detection process 15, a plurality of air detection steps 15.1, ..., 15.n, and, between two consecutive air detection processes 15, respectively, a de-aeration step of the system 1.

[0052] During each air detection process 15, the pumping speed of pump 5 has been modulated at 4 different speeds, from MAX to MIN.

[0053] As can be seen in figure 6, the presence of air in the hydraulic circuit 2 results in strong signal fluctuations which, however, are no longer present once the air has been eliminated.

[0054] The fluctuation measurement of the value x systematically depends on the amount of air in the water flow: In the first and second detection processes (cycles 1 and 2 from the left in figure 6), the amount of air is very large and detectable at all speeds of pump 5.

[0055] In the third detection process (cycle 3 in figure 6), the amount of air is small and detectable only at the maximum speed of pump 5.

[0056] In the fourth and fifth detection processes (cycles 4 and 5 in figure 6), the amount of air is so small or completely absent that it is no longer detectable.

Description of figure 7

[0057] Figure 7 shows the standard deviation (ordinate) of the flow rate at a constant pump speed (60% of the maximum speed) for each test cycle shown in figure 6.

[0058] In particular, figure 7 shows that the standard deviation of the flow rate at a fixed pump speed (60%) increases as the air increases in the hydraulic circuit 2 (1st and 2nd cycle in figures 6 and 7) and decreases when the air is gradually eliminated (3rd, 4th and 5th cycles in figures 6 and 7).

[0059] The samples of values acquired when performing the tests (1 sample per second) are indicated on the axis of abscissas in figure 7, taking into account a fixed number of 25 samples per detection interval.

[0060] The heating and/or cooling system 1 described so far can be installed at a house 16 or a general building. The water circulating in the hydraulic circuit 2 is brought to a desired working temperature (heated or cooled), by means of the heat and/or cold generator 4 placed in a heat exchange relationship with the hydraulic circuit 2. The control system 6 of the heat and/or cold generator 4 (e.g., gas boiler or heat pump or geothermal generator) controls the activation, shutdown, and power adjustment of the heat and/or cold generator 4, e.g., of a burner of a gas boiler or a compressor of a heat pump, as well as the activation, shutdown, and pumping speed adjustment of the circulation pump 5.

[0061] The control system 6 controls the operation of the heat and/or cold generator 4 and the circulation pump 5 as a function of one or more temperature values selectable by a user by means of the user interface 12 or by means of an internal environment thermostat 17 with temperature selection function, as well as, possibly, as a function of values detected by one or more of an incoming water temperature sensor 18 at the inlet of the heat exchanger 22 of the heat and/or cold generator 4, an outgoing water temperature sensor 19 at the exit of the heat exchanger 22 of the heat and/or cold generator 4, an external ambient temperature sensor 20, an internal ambient temperature sensor 21 (figure 1).

[0062] Therefore, the system 1 (e.g., a boiler system or a heat pump system or a geothermal system) described so far can also be manufactured and marketed without and irrespective of the hydraulic heating circuit 2 to which it is connectable, for example, for new installations or for replacing old gas boilers or heat pumps.

List of Reference signs

[0063]

- heating or cooling system 1
- hydraulic circuit 2
- heating or cooling devices 3
- heat or cold generator 4
- circulation pump 5
- electronic control system 6
- air detection module 7, 7'
- flow rate sensor 8
- indirect determination device 9
- electric motor 10
- heat/cold generator housing 11

user interface 12
 further user interface 12'
 remote server 13
 remote electronic device 14
 5 air detection process 15
 air detection steps 15.1, ...15.n.
 house 16
 internal environment thermostat 17
 incoming water temperature sensor 18
 10 outgoing water temperature sensor 19
 external ambient temperature sensor 20
 internal ambient temperature sensor 21
 heat exchanger 22
 pump activation step F1
 15 parameter detection step F2
 value collection step F3
 variation calculation step F4
 comparison step F5
 notification signal generation step F6
 20 user command insertion step F7
 activation criterion verification step F8
 anomaly notification step F9
 maintenance preparation step F10
 predictive maintenance step F11
 25

Claims

1. A heating or cooling system (1), in particular domestic, comprising:

a heat or cold generator (4) connectable in a heat exchange relationship to a hydraulic heating and/or cooling circuit (2),
 a circulation pump (5), connectable to the hydraulic circuit (2), to convey a flow of water into the hydraulic circuit (2),
 35 an electronic control system (6) in signal connection with the heat or cold generator (4) and with the circulation pump (5), to control the operation of the heat or cold generator (4) and the circulation pump (5),
characterized by comprising:

an air detection module (7, 7') configured so as to perform an air detection process (15),
 40 comprising one or more air detection steps (15.1, ..., 15.n), wherein:

- with the circulation pump (5) activated at a circulation speed, it detects a parameter (x) indicative of the flow rate of the water inside the hydraulic circuit (2),
- it collects a plurality of values (x_t) of the parameter (x) detected in a detection time interval,
- 45 - it calculates a variation (FlowRate_StdDev) of the plurality of values (x_t) collected in the detection time interval,
- it compares the calculated variation (FlowRate_StdDev) with a variation threshold value (Threshold_var) and:

50 if the calculated variation (FlowRate_StdDev) is greater than the variation threshold value (Threshold_var), it generates a notification signal of air presence in the hydraulic circuit (2), and
 if the calculated variation (FlowRate_StdDev) is lower than the variation threshold value (Threshold_var), it does not generate the notification signal of air presence in the hydraulic circuit.

2. A system (1) according to claim 1, wherein the air detection module (7, 7') is configured so that, if during a first air detection step (15.1) of the air detection steps (15.1, ..., 15.n), with a first pumping speed of the circulation pump (5), the calculated variation (FlowRate_StdDev) is lower than the variation threshold value (Threshold_var), the air detection module (7, 7') performs a further subsequent air detection step (15.2), with a further pumping speed of

the circulation pump (5) different from the first pumping speed.

3. A system (1) according to claim 2, wherein the air detection module (7, 7') performs the first air detection step (15.1) with a first pumping speed and the subsequent air detection step(s) (15.2, ..., 15.n) with pumping speeds that decrease from one air detection step (15.n-1) to the subsequent air detection step (15.n).

4. A system (1) according to any one of the preceding claims, wherein within the same air detection step (15.n) the pumping speed of the circulation pump (5) is constant,

e/o wherein the duration of the detection interval is constant,

e/o wherein the number of values (x) detected and collected during the detection interval is constant,

e/o wherein the variation threshold value (Threshold_var) is different for different pumping speeds of the circulation pump (5).

5. A system (1) according to any one of the preceding claims, wherein the notification signal of air presence in the hydraulic circuit (2) triggers:

- a visual and/or acoustic notification and/or,

- an automatic anomaly control process on the heat or cold generator (4) and/or the circulation pump (5), and/or

- a safety shutdown of the heat or cold generator (4) and the circulation pump (5).

6. A system (1) according to claim 5, wherein the visual and/or acoustic notification takes place by a user interface (12) of the electronic control system (6) of the system (1), positioned for example directly on board the heat or cold generator (4) or externally thereto, or by a further user interface (12') of the air detection module (7') positioned externally to the electronic control system (6).

7. A system (1) according to any one of the preceding claims, wherein the air detection module (7) is directly integrated into the electronic control system (6) of the heating or cooling system (1),

e/o wherein the air detection module (7') is an external electronic processing module (7') with respect to the electronic control system (6) and connectable to the system (1) temporarily or permanently as a retrofit accessory, e/o wherein the notification signal of air in the hydraulic circuit (2) triggers the transmission of an anomaly notification signal to a remote server (13) which, in response to receiving the anomaly notification signal, performs a maintenance preparation process.

8. A system (1) according to any one of the preceding claims, wherein the air detection module (7, 7') is configured to:

- enable the manual entry of a start command for the air detection process (15), and

- in response to the start command for the air detection process (15), perform the air detection process (15).

9. A system (1) according to any one of the preceding claims, wherein the air detection module (7, 7') is configured to perform the air detection process (15) automatically as a function of a predetermined starting criterion.

10. A system (1) according to claim 9, wherein the starting criterion is chosen from the group consisting in:

- a predetermined time interval,

- a performed detection, by the electronic control system (6) or the air detection module (7, 7'), of a water flow anomaly in the hydraulic circuit (2),

- the performed detection, by the electronic control system (6) or the air detection module (7, 7'), of a temperature control anomaly on the heating or cooling system (1).

11. A system (1) according to any one of the preceding claims, wherein the air detection module (7, 7') obtains the parameter (x) indicative of the flow rate:

- from a flow rate signal provided by the circulation pump (5), or

- from a signal of a flow rate sensor (8) connected to the hydraulic circuit (2) externally to the circulation pump (5), or

- from a head signal generated by the circulation pump (5), or

- from a signal of electric power or electric current value absorbed by the electric motor (10) of the circulation

pump (5), or

- from a signal of the number of revolutions or angular speed of the electric motor (10) of the circulation pump (5).

12. A system (1) according to any one of the preceding claims, wherein the air detection module (7, 7') performs the calculation of the variation (FlowRate_StdDev) of the plurality of values (x_t) by calculating:

- the standard deviation of the plurality of values (x_t) collected in the detection time interval, or
- the variation coefficient, i.e. the relative standard deviation of the plurality of values (x_t) collected in the detection time interval, or
- a mean value of the absolute differences between all the values of the plurality of values (x_t) and a mean value of all the values of the plurality of values (x_t), or
- a mean value of the absolute differences between all the values of the plurality of values (x_t) and a central value half way between a maximum value and a minimum value of all the values of the plurality of values (x_t).

13. An air detection process (15) in a heating or cooling system (1), in particular domestic, of the type comprising:

a heat or cold generator (4) connected in a heat exchange relationship to a hydraulic heating and/or cooling circuit (2),
 a circulation pump (5), connected to the hydraulic circuit (2), to convey a flow of water into the hydraulic circuit (2),
 an electronic control system (6) in signal connection with the heat or cold generator (4) and with the circulation pump (5), to control the operation of the heat or cold generator (4) and the circulation pump (5),

characterized in that the air detection process (15) comprises one or more air detection steps (15.1, ..., 15.n), wherein:

- with the circulation pump (5) activated (F1) at a circulation speed, detecting a parameter (x) indicative of the flow rate of the water flow inside the hydraulic circuit (2) (F2),
- collecting a plurality of values (x_t) of the parameter (x) detected in a detection time interval (F3),
- calculating a variation (FlowRate_StdDev) of the plurality of values (x_t) collected in the detection time interval (F4),
- comparing the calculated variation (FlowRate_StdDev) with a variation threshold value (Threshold_var) (F5) and:

if the calculated variation (FlowRate_StdDev) is greater than the variation threshold value (Threshold_var), generating a notification signal of air presence in the hydraulic circuit (2) (F6), and
 if the calculated variation (FlowRate_StdDev) is lower than the variation threshold value (Threshold_var), not generating the notification signal of air presence in the hydraulic circuit.

14. A process (15) according to claim 13, wherein, if during a first air detection step (15.1) of the air detection steps (15.1, ..., 15.n), with a first pumping speed of the circulation pump (5), the calculated variation (FlowRate_StdDev) is lower than the variation threshold value (Threshold_var), performing a further air detection step (15.2), using a further pumping speed of the circulation pump (5) different from the first pumping speed.

15. A process (15) according to claim 14, comprising:

- performing the first air detection step (15.1) with a first pumping speed and the subsequent air detection step(s) (15.2, ..., 15.n) with pumping speeds that decrease from one air detection step (15.n-1) to the subsequent air detection step (15.n).

16. A process (15) according to any one of claims 13 to 15, comprising:

- in response to the notification signal of air presence in the hydraulic circuit (2), transmitting an anomaly notification signal (F9) to a remote server (13) which, in response to receiving the anomaly notification signal, performs a maintenance preparation process (F10),
 e/o comprising:

- enabling the manual entry of a start command (F7) for the air detection process (15) in a user interface, and

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- in response to the start command for the air detection process (15), perform the air detection process (15),

e/o comprising:

5 performing the air detection process (15) automatically as a function of a predetermined starting criterion.

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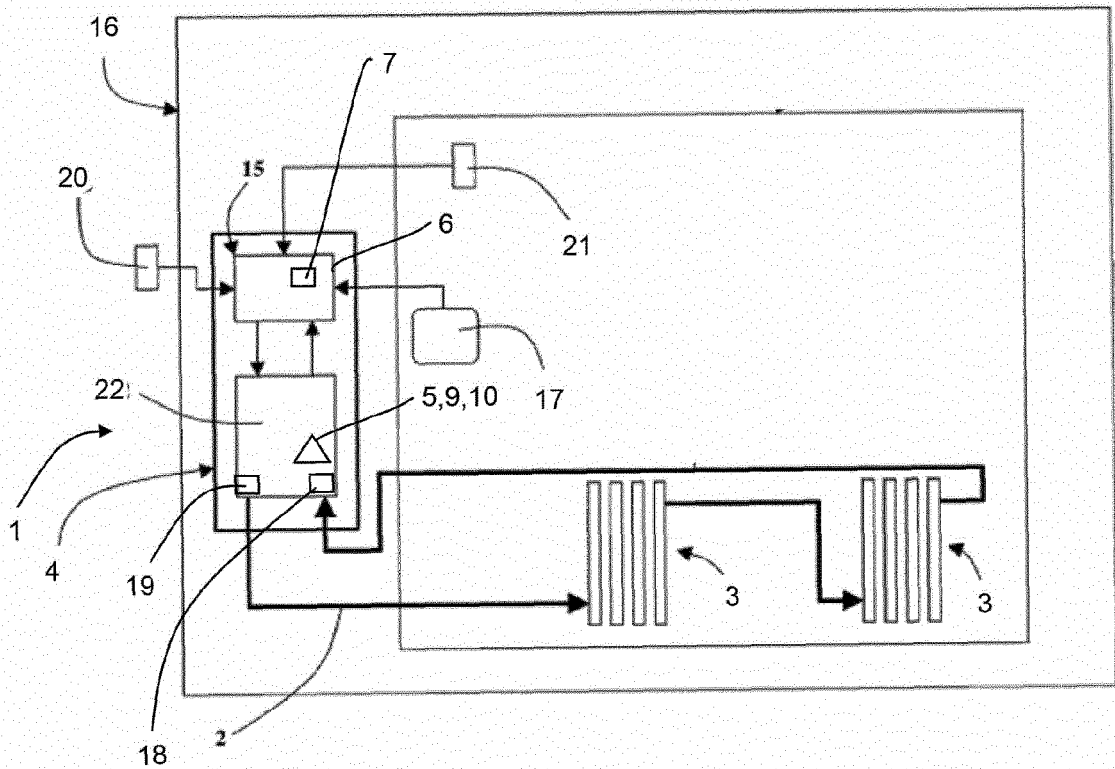


FIG. 1

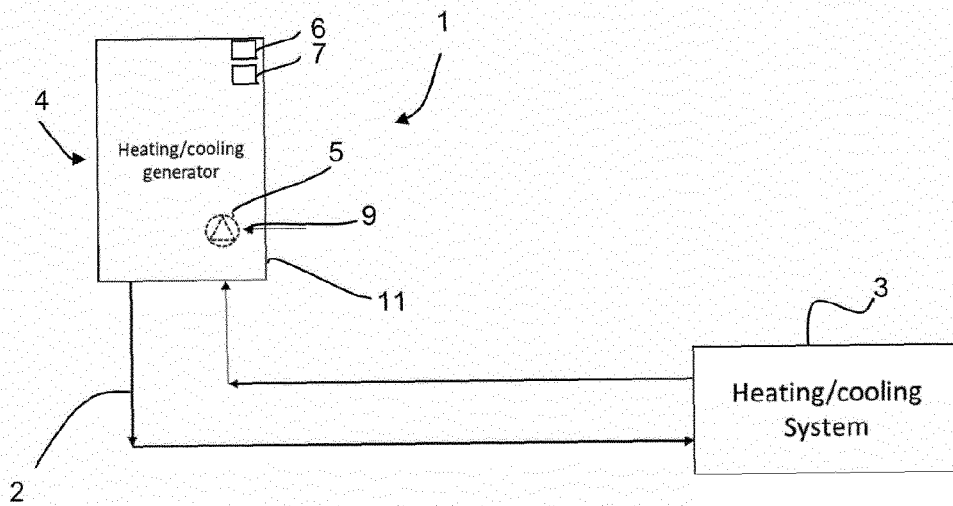


FIG. 2

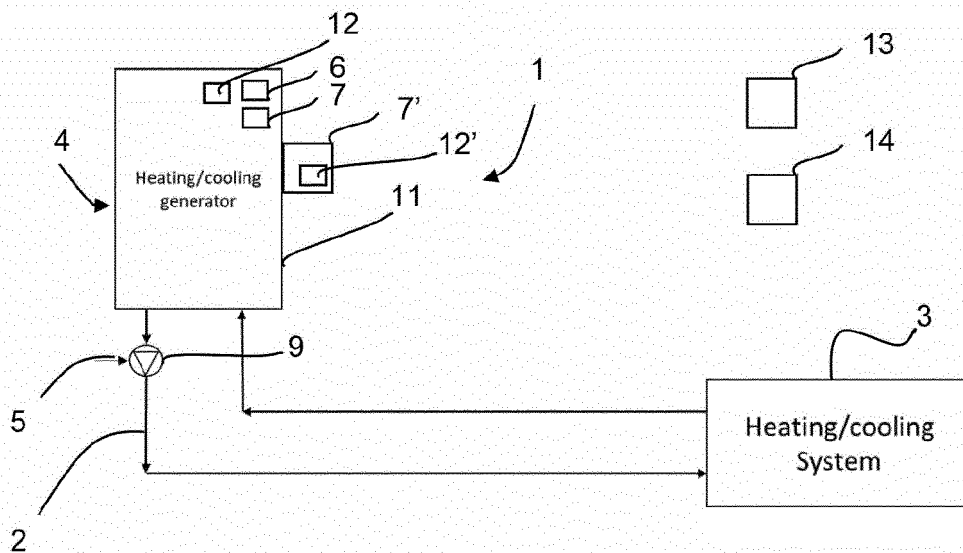


FIG. 3

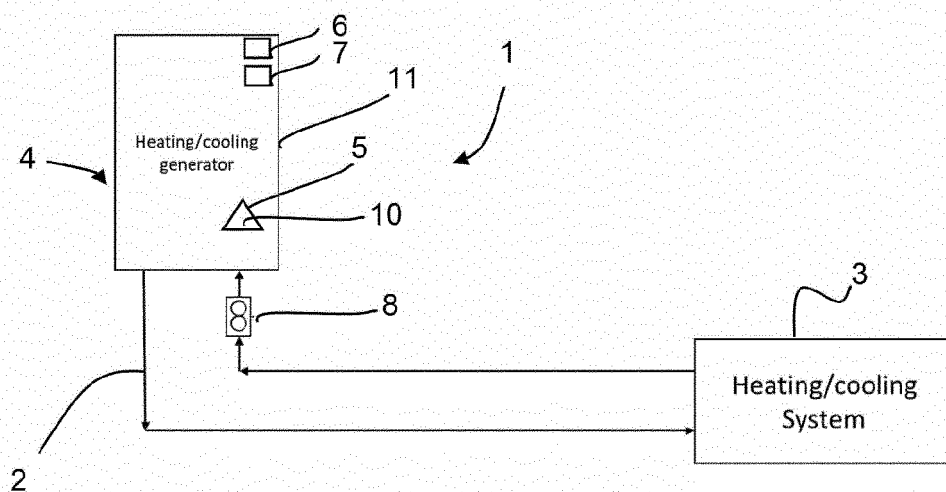


FIG. 4

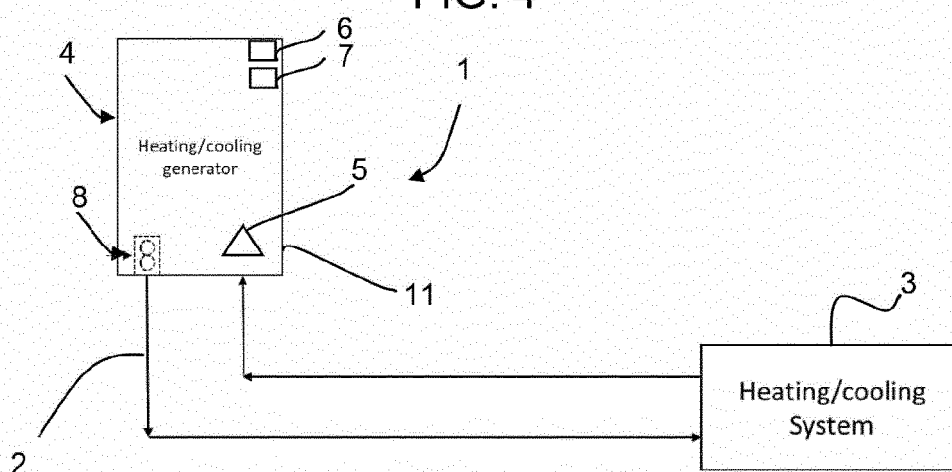


FIG. 5

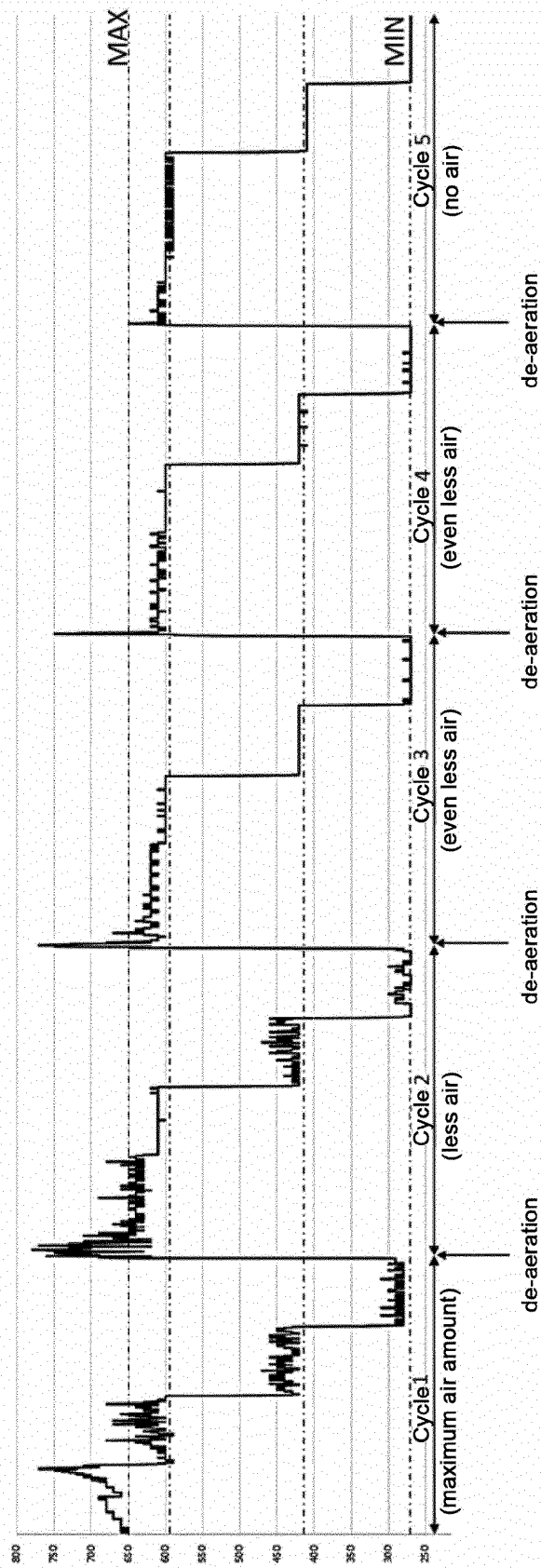


FIG. 6

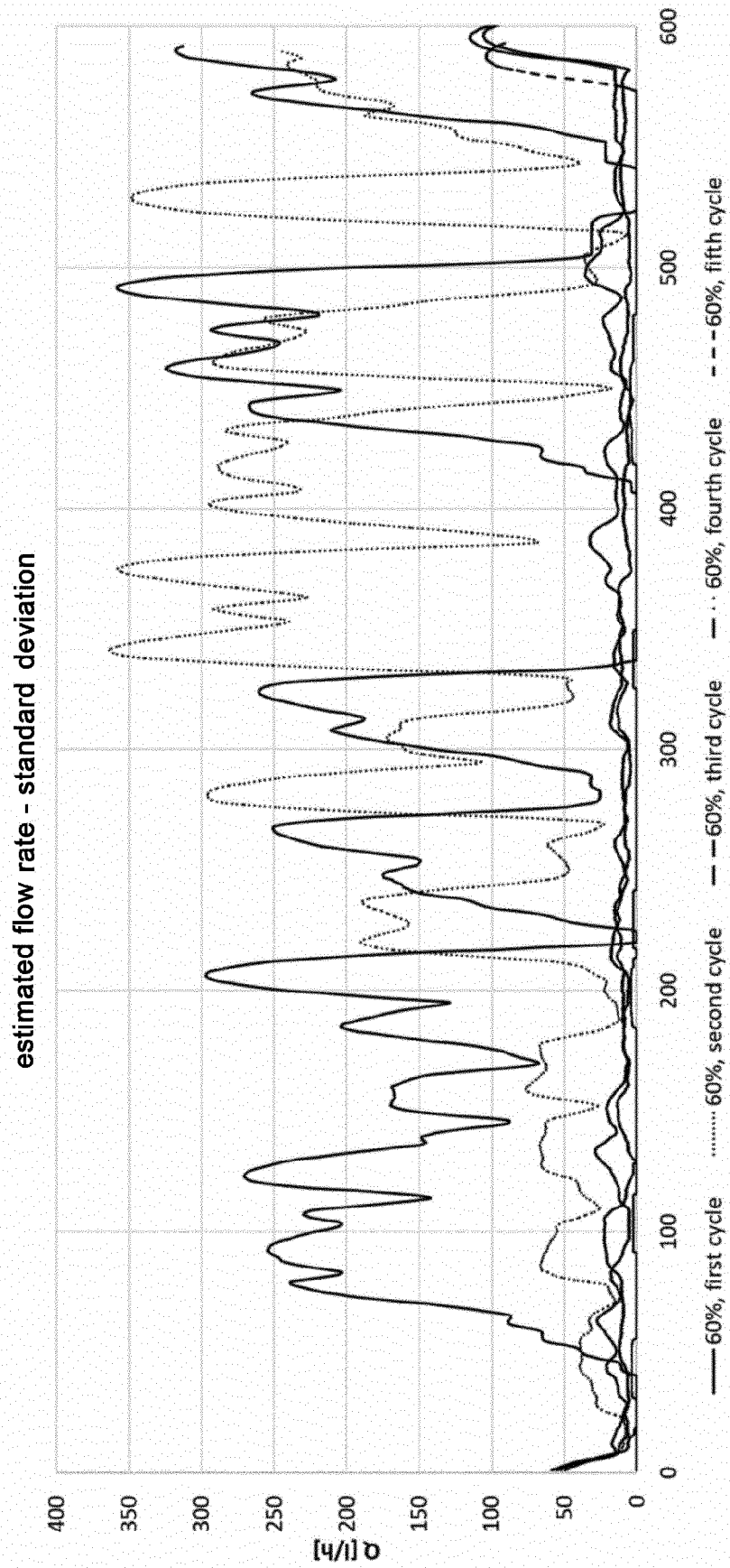


FIG. 7

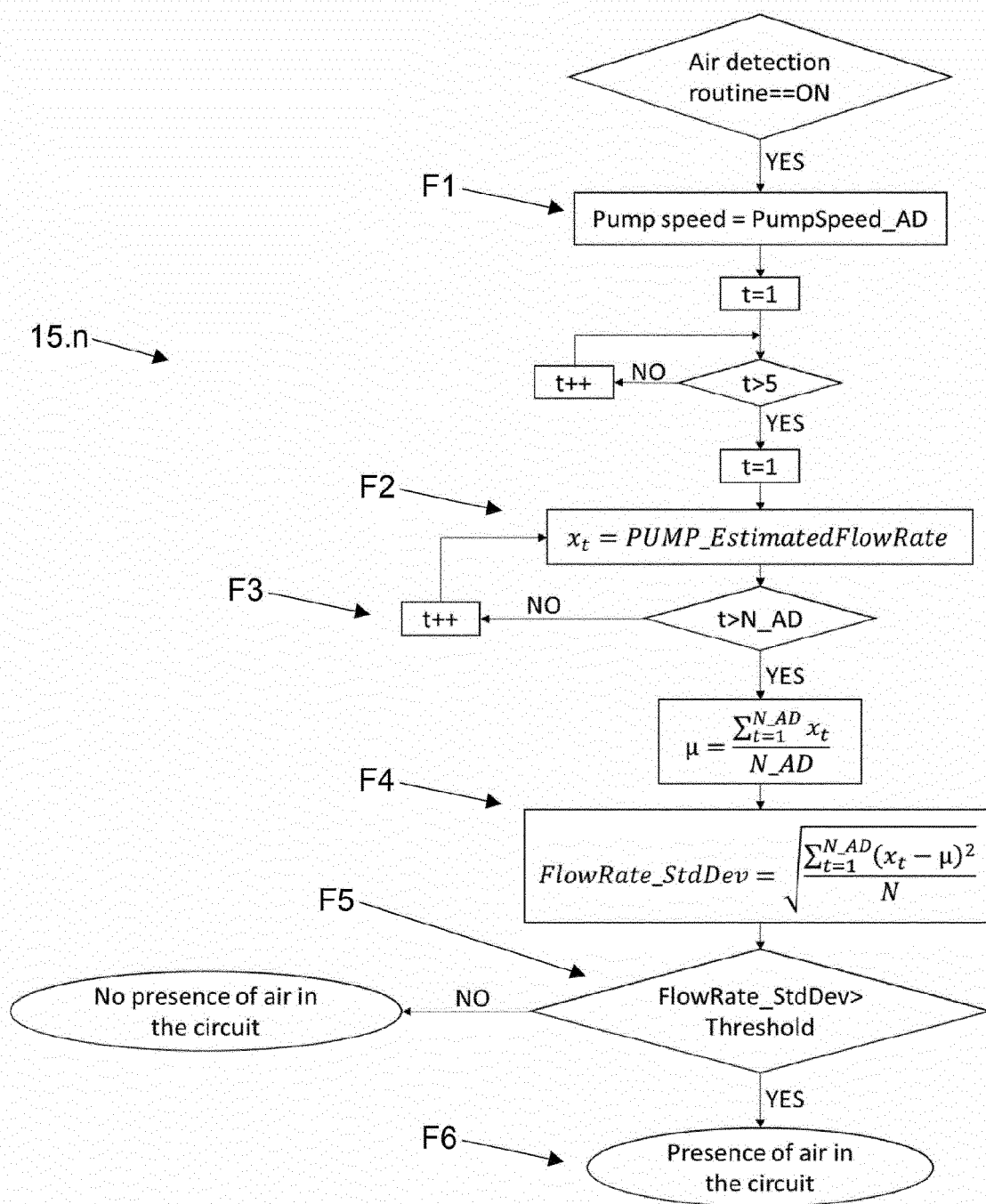


FIG. 8

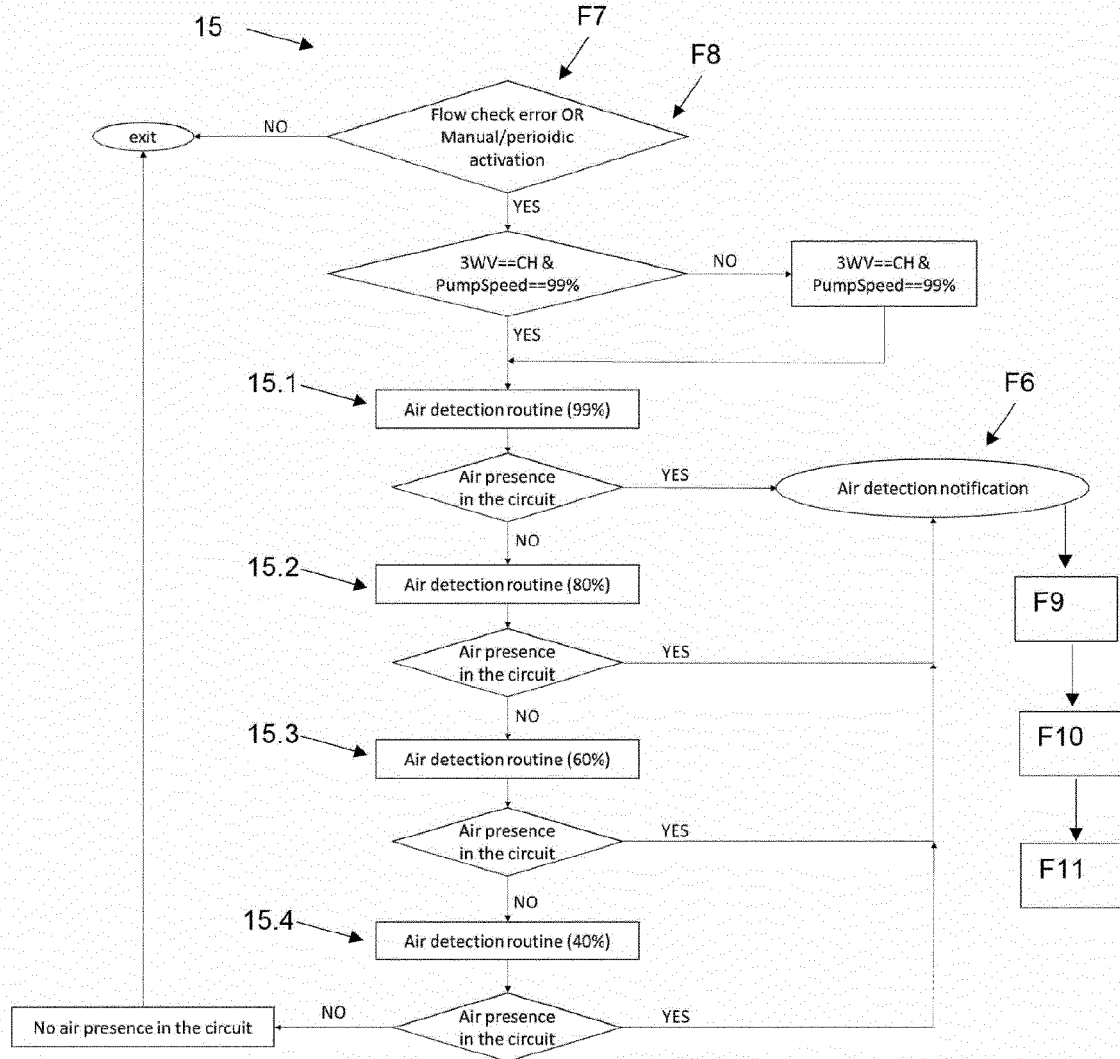


FIG. 9



EUROPEAN SEARCH REPORT

Application Number

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A	EP 1 593 916 B1 (WILO SE [DE]) 20 June 2012 (2012-06-20) * the whole document *	1, 13	
A	KR 2004 0081983 A (LOTTE ENG & MACHINERY MFG CO) 23 September 2004 (2004-09-23) * the whole document *	1, 8	
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			F24D F24H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 7 November 2023	Examiner Ast, Gabor
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The members are as contained in the European Patent Office EDP file on
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07-11-2023

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