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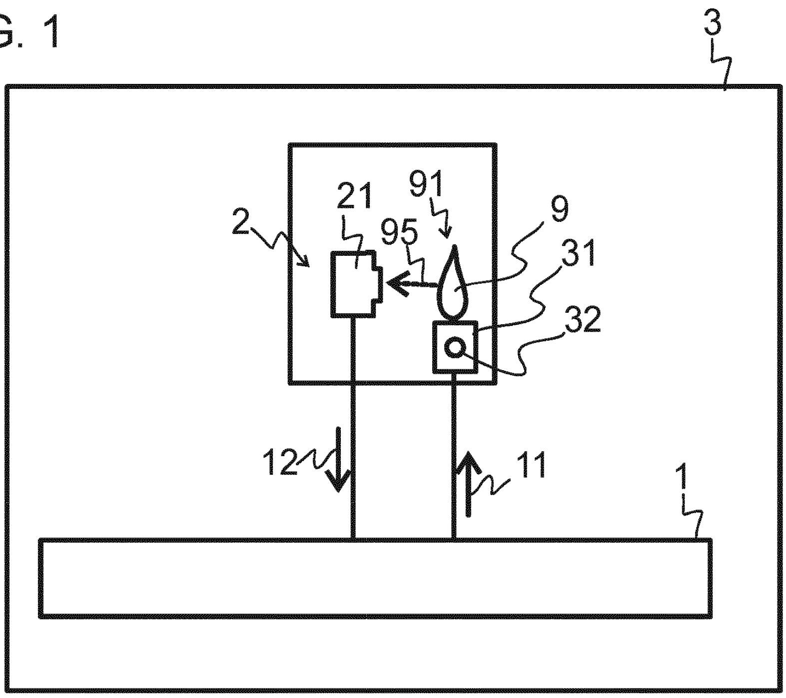
(54) COMBUSTION SENSOR CONTROL

(57) The invention proposes systems and methods for automatic testing of a flame sensor configuration. The flame sensor configuration (2) is adapted for monitoring the functioning of a combustion appliance (3) by monitoring a flame (9) of the combustion appliance (3). An operation parameter of the combustion appliance (3) intended to result in a change of a characteristic of the flame (9) is automatically changed. Automatic assessment is comprised whether the intended change of the characteristic of the flame (9) is detected by the flame sensor configuration (2).

FIG. 1



EP 4 397 907 A1

Description

[0001] The instant disclosure generally relates to the technical field of sensor control for flame monitoring in combustion appliances.

[0002] In particular, the instant disclosure relates to burners and boilers which burn fluid fuels, preferably gaseous fuels, preferably during continuous operation. For continuous operation, the function of the flame monitoring sensor shall be tested regularly, preferably according to DIN EN298 in the latest accepted version of DIN EN 298:2012-11, or in the draft version of DIN EN 298:2020-09. For intermittent operation, the flame monitoring sensor shall preferably be tested at each burner start-up sequence. Intermitted Systems are usually designed to remain in the running position for less than 24 hours.

[0003] Several methods for testing whether the flame monitoring sensors for continuous operation work properly are known in the art:

DE 196 45 555 A1 discloses a flame sensor arrangement in which the light path from the burner flame to a sensor element is interrupted by a shutter.

DE 10 2004 028 473 A1 discloses an apparatus for testing a flame control apparatus that is equipped with a light sensor. The light sensor is disposed in the light path of the flame that is to be controlled. The sensor is preferably a photo diode to which an additional radiation source is assigned that is suited to send electromagnetic radiation of a defined frequency and intensity.

DE 198 41 475 C1 discloses a system and a method for monitoring a flame by means of a flame sensor. A signal amplifier is switched off in case a test signal is present.

EP 2 439 451 A1 discloses an appliance for recognizing the presence of a flame with two redundant sensors.

EP 3 339 736 B1 discloses a sensor configuration for a combustion appliance comprising a sensor configured to produce a signal offset when receiving at least 1.1 Lux, focusing on a circuit for use in combustion appliances for fossil fuels.

DE 42 06 555 A1 discloses a photoelectric circuit that is capable to detect only the signal light component in order to avoid disturbances by disturbing or side light.

[0004] It is an object of the present disclosure to simplify automatic testing of a flame sensor configuration. This object is achieved by the solutions presented in the independent claims.

[0005] According to an aspect a control system is proposed. The control system is configured for automatically testing a flame sensor configuration. The flame sensor configuration is configured for monitoring the functioning of a combustion appliance by monitoring a flame of the combustion appliance. The control system is adapted for processing a control signal related to an intended causing of the combustion appliance to change an operation parameter resulting in a change of a characteristic of the flame. The characteristic is detectable by the flame sensor configuration. The control system is furthermore adapted for receiving and processing a sensor signal received from the sensor configuration, said sensor signal carrying an information detected by the flame sensor configuration about the characteristic of the flame. The processing of the sensor signal comprises assessing whether the intended change of the characteristic of the flame actually is detected by the flame sensor configuration.

[0006] According to a further aspect a flame sensor configuration for monitoring the functioning of a combustion appliance is proposed. The flame sensor configuration comprises said control system, and a flame sensor for generating the sensor signal based on detecting the characteristic of the flame.

[0007] According to a further aspect a combustion appliance is proposed. The combustion appliance comprises said flame sensor configuration, and a burner, wherein the burner is configured to generate said flame.

[0008] According to a further aspect a method for automatically testing a flame sensor configuration is proposed. The flame sensor configuration is adapted for monitoring the functioning of a combustion appliance by monitoring a flame of a combustion appliance. According to the method, an operation parameter of the combustion appliance is changed. The characteristic is detectable by the flame sensor configuration. In case the combustion appliance works properly, the change of the operation parameter results in a change of a characteristic of the flame. The flame sensor configuration is then tested by automatically assessing whether the intended change of the characteristic of the flame is actually detected by the flame sensor configuration.

[0009] According to a further aspect a computer program is proposed. The computer program comprises instructions to cause the proposed control system to execute the steps of the proposed method.

[0010] According to a further aspect a computer-readable medium is proposed. The computer-readable medium has stored there on the proposed computer program.

[0011] More specific embodiments are presented in an exemplary manner in the independent claims.

[0012] According to an embodiment the control system is adapted for generating the control signal, and the control signal causes the combustion appliance to change the operation parameter resulting in the change of the characteristic of the flame.

[0013] According to further embodiments, the combustion appliance is adapted for burning a fluid fuel in a controlled manner in order to produce the flame. This allows a combustion appliance to change an operation parameter resulting in a change of a characteristic of the flame in a simple manner. On the other hand, fluid fuels are more dangerous in case of a failure of the combustion appliance. This risk can be reduced according to these embodiments. Among the fluid fuels, gaseous fuels bear an even higher risk than liquid fuels, because they can accumulate in a building or facility and result in dangerous explosions when ignited. Preferably, the combustion appliance is therefore adapted for burning gaseous fuels, for example for burning ethane, methane, propane, butane, or hydrogen (H2), natural gas, biogas, carbon monoxide, or other combustible gases. Of course, according to embodiments of the invention, the gaseous fuel can comprise any suitable gaseous fuel, including any suitable mixture of the previously mentioned gaseous fuels.

[0014] In further embodiments, the combustion appliance is adapted for burning liquid fuel, such as for example fuel oil, diesel, alcohol, other liquid fuels, or any suitable mixture of these liquid fuels.

[0015] According to further embodiments, the flame sensor configuration is a light sensor configuration comprising at least one light sensor adapted and arranged for detecting light emitted by the flame. This allows for a simple and cost-effective solution for monitoring a flame. "Light" is thereby not limited to the visible spectrum of light. Instead, light encompasses any electromagnetic radiation suitable for representing the change in the characteristic of the flame. For example, the light sensor can therefor also be an infrared sensor or an ultraviolet sensor, since many combustion appliances produce flames emitting light in infrared, visible, and/or ultraviolet spectrum.

[0016] According to further embodiments, the change of the characteristic of the flame is a change in a signature of light emitted by the flame. The term signature in this context encompasses any selection of physical properties of light emitted by the flame suitable to represent the change of the characteristic of the flame. Suitable physical properties can for example be a spectrum of light emitted by the flame, an intensity of light emitted by the flame, a spectral intensity of light emitted by the flame, wherein a spectral intensity is the intensity of one or more intervals in the spectrum of emitted light.

[0017] For example, the light sensor can be a sensor detecting ultraviolet light. Ultraviolet sensors are particularly well suited for detecting flames produced by gaseous fuels, since, as a rule of thumb, gaseous fuels emit mainly in the ultraviolet spectrum and in the infrared spectrum. Of course, for detecting a change in a flame produced by a gaseous fuel, infrared detectors, and detectors detecting visible light can also be used.

[0018] As another rule of thumb, liquid oil fuels mainly emit light in the visible spectrum. Therefore, according to other embodiments, the light sensor is a sensor detecting visible light.

[0019] However, it is to be understood, that the invention is likely to work in at least many situations when the above rules of thumb are not followed, since flames produced by gaseous or liquid fuels usually emit light over a large spectrum which can reach from infrared to visible to ultraviolet light.

[0020] According to further embodiments, the flame sensor configuration comprises an analogue sensor signal output which is used for said testing of the flame sensor configuration. This allows for a reliable means for detecting changes in flame characteristics, and transporting said characteristics in the sensor signal.

[0021] According to further embodiments, the flame sensor configuration is a flame ionization detector configuration comprising a flame ionization detector.

[0022] According to further embodiments, the sensor signal, be it digital or analog, is suited to indicate changes in the characteristic of the flame. The signal thereby transports the change in the characteristic of the flame in a more detailed manner than only a simple one-digit binary. This allows the sensor signal to transport an information describing the change of the characteristic of the flame in a quantitative manner, and thus allows to test the flame sensor configuration while the combustion appliance is operative. In other words, this allows to test the combustion appliance without the flame going out.

[0023] According to further embodiments, the characteristic of the flame is a frequency and/or an amplitude. For example, in case oxygen supply to the flame is reduced, the flame might become erratic and show significant fluctuations. These fluctuations can be in the amplitude and/or in the frequency.

[0024] According to further embodiments, the signal represents an increase or a decrease of a characteristic of the flame.

[0025] According to further embodiments, the testing of the flame is performed during continuous operation of the combustion appliance. In other words, the testing of the flame is performed without the flame being interrupted completely. Accordingly, the control signal is related to an intended causing of the combustion appliance to change an operation parameter during continuous operation of the flame. For example, the sensor signal is generated by the control system and in case the combustion appliance works properly, said control signal causes to the combustion appliance to change the operation parameter. According to this embodiment, the sensor configuration is preferably configured to detect at least two different values of the characteristic of the flame, each different value of the characteristic corresponding to at least one different value of the operation parameter of the flame. Preferably, the sensor configuration is configured to detect at least three different values of the characteristic of the flame, at least two of the at least three detectable different values of the characteristic corresponding to at least one different value of the operation parameter of the flame, and at least one of the at least three detectable different values of the characteristic corresponding to a switched off flame.

[0026] According to further embodiments, the testing of the flame sensor configuration is initiated at predetermined moments. For example, the control signal related to the intended causing of the combustion appliance to change an operation parameter resulting in a change of a characteristic of the flame is generated at predetermined moments or regular intervals.

[0027] According to further embodiments, the changing of the operation parameter of the combustion appliance is performed by changing an amount of fuel applied to the flame and/or by changing an amount of combustion air applied to the flame. The changing, can thereby be performed by changing a ratio of fuel to combustion air. Alternatively, the changing can also be performed by changing at least one absolute amount of fuel and/or combustion air. According to another embodiment, the changing of the operation parameter of the combustion appliance is performed by changing or switching off a recirculation of exhaust gas.

[0028] However, there are also combustion appliances with burners that include a pilot flame. The pilot flame is used for igniting a usually larger main flame. In further embodiments, the pilot flame could be switched on or off during regular operation. This allows for changing a flame characteristic without changing a fuel ratio and/or air ratio. Nevertheless, a sufficiently sensitive enough flame sensor configuration could be capable of registering a change in the flame characteristic, since the flame is then differently distributed, and will be registered to be more intense or less intense by the flame sensor configuration.

[0029] According to an embodiment, the control system can be one single unit. However, according to other embodiments the control system does not need to be arranged in one single casing or integrated circuit or controller or computer or the like. The control system can thus also be a distributed control system, such that parts of the control system are physically included in other parts of the combustion appliance or flame sensor configuration. For example, a subsystem of the control system that generates the control signal for causing the combustion appliance to change the operation parameter can also be included in a casing that holds the sensor or the entire sensor configuration. Also, said subsystem can be arranged in a casing that holds a combustion appliance control system. According to further embodiments, the control system, a sensor control system, and a combustion appliance control system can be partially or entirely integrated in one single chip or integrated circuit.

[0030] Various features will become apparent to those skilled in the art from the following detailed description of the disclosed non-limiting embodiments. The drawings that accompany the de-tailed description can be briefly described as follows:

FIG 1 schematically depicts a block diagram of a combustion appliance comprising a flame sensor configuration, and a control system according to an embodiment of the invention;

FIG 2 schematically depicts a block diagram of a combustion appliance comprising a flame sensor configuration, and a control system according to an embodiment of the invention;

FIG 3 schematically depicts a block diagram of a combustion appliance comprising a flame sensor configuration, and a control system according to an embodiment of the invention;

FIG 4 schematically depicts a flow chart of an exemplary method for automatically testing a flame sensor configuration according to an embodiment of the invention;

FIG 5 shows schematically a block diagram of an architecture of the control system according to an embodiment of the invention;

FIG 6 shows an exemplary graph of a simulation of a control signal and sensor signal;

FIG 7 shows an exemplary graph of a processed sensor signal and its evaluation;

FIG 8 shows the exemplary graph of FIG 6 over a longer period of time;

FIG 9 shows an exemplary graph of FIG 7 over a longer period of time.

[0031] Figure 1 shows a combustion appliance 3 in accordance with an embodiment of the invention. The combustion appliance 3 comprises a control system 1 according to an embodiment of the invention, a sensor configuration 2, and a burner 31 for producing a flame 9 by burning fuel. The control system 1 is connected to the burner 31 and to the sensor 21 for controlling these two devices 21, 31.

[0032] The flame sensor configuration 2 is configured to detect a characteristic of the flame 9. In this embodiment, the flame sensor configuration 2 is a light sensor configuration comprising a light sensor 21. Light sensor 21 is arranged in a light path 95 of the light emitted by the flame 9. Light sensor 21 is configured for measuring an intensity of light emitted in a given spectrum by the flame 9. The spectrum does not need to be in the visible spectrum, but can be any suitable electromagnetic spectrum, including an ultraviolet and/or infrared spectrum.

[0033] The control system 1 is configured to generate a control signal 11 for causing the combustion appliance 3 to change an operation parameter 32 resulting in a change of a characteristic 91 of the flame 9 detectable by the flame sensor configuration.

[0034] For example, the control system 1 and the burner 31 can be configured that the control signal 11 is sent to the burner 31. The control signal 11 causes the burner to change an amount of fuel applied to the flame 9 and/or an amount of combustion air applied to the flame 9. The amount of fuel applied to the flame 9 and the amount of combustion air applied to the flame 9 are therefore examples of operation parameters 32. The at least one operation parameter 32 is changed in such a manner that the combustion appliance 3 continuously operates without interrupting or letting the flame 9 go out completely.

[0035] The flame sensor configuration 2 is configured to detect the characteristic of the flame 9 and to send sensor signals 12 to the control system 1. The sensor signals 12 comprise a representation of the characteristic. Consequently, when operating properly, the flame sensor configuration 2 is configured to detect the change in the characteristic of the flame 9 and to send a sensor signal 12 to the control system 1 that includes a representation of the changed characteristic.

[0036] The control system 1 is configured to test proper functioning of the flame sensor configuration 2 based on whether a sensor signal 12 indicates a change in the characteristic of the flame 9 that corresponds to the changed flame parameter. In this sense, the control system 1 is configured to test the reliability of the flame sensor configuration 2. Technically this can be achieved by the control system 1 by assessing whether a change in the signals 12 sent to the control system 1 sufficiently coincides with the signal 11.

[0037] In the embodiment of figure 1 the setup of the flame sensor configuration comprises one single light sensor 21 with an analogue signal output 12 which is tested during continuous operation by modulating the flame 9 itself to modulate the light intensity and thus the sensor signal 12.

[0038] During the test procedure the control unit 1 managing the burner modulates the flame 9 and subsequently expects a corresponding change in sensor signal 12. This procedure detects a stuck-at failure of the flame sensor 9 and thus guarantees the normal function of the sensor configuration 2. The fuel-air-mixture can be made leaner to avoid unclean burner conditions. In case of a combustion control by evaluating the flame sensor signal 12 it may be interesting to enrich the mixture, too.

[0039] Sensor output signal 12 is configured to transport a change of the characteristic of the flame corresponding to the change of the operation parameter of the combustion appliance. In other words, the sensor is configured to signal an increase or a decrease of the characteristic of the flame 9 to the control unit.

[0040] According to an embodiment, the control unit 1 can be configured as an analogue circuit. According to another embodiment, the control unit can comprise or be configured as a digital control unit comprising an analogue-digital-converter to which analogue sensor output is fed, for being converted to a digital signal that is processed by the control unit. In other embodiments, the output of the sensor 21 is digital or the sensor comprises an analogue-digital-converter that feeds a digitalized signal to the control unit 1.

[0041] According to some embodiments, the control system 1 can be, but does not need to be arranged in one single casing or integrated circuit or controller or computer or the like. Control system 1 can also be a distributed control system, such that parts of the control system are physically included in other parts of the combustion appliance 3 or flame sensor configuration 2.

[0042] For example, in some embodiments a subsystem of the control system 1 that generates the control signal for causing the combustion appliance 3 to change the operation parameter 32 can also be included in a casing that holds the sensor 21 or the entire sensor configuration 2. For example, said subsystem can be arranged in a casing that holds a combustion appliance control system. When the subsystem submits a control signal 11 to the combustion appliance for causing the combustion appliance 3 to change an operation parameter 32 in order to start the testing of the flame sensor configuration 2, a further control signal is also sent to the control system 1 to indicate that the testing has started, so that the control system 1 is able to assess whether sufficient coincidence with a change of the flame characteristic is signaled by the sensor 21 via sensor signals 12.

[0043] According to further embodiments, the control system 1, a sensor control system, and a combustion appliance control system can be partially or entirely integrated in one single chip or integrated circuit.

[0044] For the understanding of the present invention, the term "control system" is not limited to a physical control system located in one single casing, chip, integrated circuit or the like. The term control system, particularly the control system 1 as defined by the claims should be understood as a logical or functional control system for automatically testing a flame sensor configuration. Parts of this logical or functional control system can be located in different physical entities of the combustion appliance or flame sensor configuration.

[0045] Figure 2 shows a combustion appliance 203, in which the control system 1 is integrated into the flame sensor configuration 202. Such a solution is particularly suited for upgrading an existing combustion appliance, such as an existing boiler or burner appliance. The control signal 11 for starting the testing of the sensor configuration 202 is sent to a previously to the upgrading installed burner control system 15, causing it to change an operation parameter 32 of the combustion appliance 3 resulting in a change of a characteristic of the flame 9. The control system 1 can then assess proper functioning of the flame sensor configuration 202 by processing a sensor signal 12 received from the flame sensor 221 of the flame sensor configuration 201, said sensor signal 12 carrying an information detected by the flame sensor configuration 202 about the characteristic of the flame 9. Said processing of the sensor signal 12 comprises assessing whether the intended change of the characteristic 91 of the flame 9 is detected by the flame sensor configuration 202.

[0046] Figure 3 shows a combustion appliance 303, in which the control system 1 is distributed at different locations. The control system 1 comprises the burner control system 15, a test initiation system 301a, and a test control system 301b. The test initiation system 301a is integrated into the flame sensor 321, while the control system 301b is arranged outside of the flame sensor 321. The control signal 11 is initiated by the test initiation system 301a and sent via test control system 301b or directly or via another path to the burner control system 15, causing the burner control system to change an operation parameter 32 of the burner 31 resulting in a change of a characteristic of the flame 9.

[0047] The sensor signal 12 is generated by the sensor 321, and forwarded to the test control system 301b, said sensor signal 12 carrying an information detected by the flame sensor configuration 302 about the characteristic of the flame 9. Test control system 301b processes the sensor signal 12 by assessing whether the expected change of the characteristic 91 due to the changed operation parameter of the burner is actually detected by the flame sensor configuration 302.

[0048] In further embodiments, the flame sensor configuration comprises a flame sensor which is self-monitored. The self-monitored flame sensor is configured to control the burner 32 directly, and thus sends out the control signal directly to the burner 32 for changing an operation parameter 32. The self-monitored flame is configured to monitor the flame 9, and to test, whether a corresponding change in the characteristic of the flame 9 is measured as a consequence of the control signal.

[0049] In another embodiment, a flame guard is arranged in a communication path between a flame 21 sensor and a burner control unit 15. The flame guard initiates the flame sensor test by generating the control signal 11.

[0050] According to a further embodiment, the flame guard processes the sensor signal 12 for testing proper operation of the flame sensor or flame sensor configuration, after having generated the control signal 11 or received a control signal from some other control unit indicating that a control signal 11 was generated causing the burner to change an operation parameter.

[0051] For example, a control unit sends a test signal to the flame guard. The flame guard stores an actual preferably filtered value of the flame, thus a value obtained by means of the flame sensor 21. The flame guard then waits for a given time period, e.g. 5 seconds for a change of the filtered value of the flame. In case said change of the filtered value is received by the flame guard, then normal operation of the combustion appliance can be resumed. In case said change of the filtered value is not observed by the flame guard, it signals to the control unit a flameout, which in turn causes closing of the fuel valves.

[0052] Figure 4 shows a flow chart of an exemplary method 400 for automatically testing a flame sensor configuration 2 according to an embodiment of the invention. The flame sensor configuration 2 is adapted for monitoring the functioning of a combustion appliance 3 by monitoring a flame 9 of the combustion appliance 3, e.g. in accordance the one of the embodiments disclosed in the context of one of the figures 1 to 3.

[0053] According to the method 400, in a method step 401 the combustion appliance 3 is turned on and/or operative, such that the burner 31 is producing the flame 9.

[0054] In method step 402, a control signal 11 is sent to the burner 31, signaling the start of the testing of the flame sensor configuration.

[0055] Control signal 11 causes in method step 403 the burner to change an operation parameter 32, intended to result in a change of a characteristic of the flame 9. In this embodiment, control signal 11 causes the burner to change an amount of gaseous fuel or an amount of combustion air supplied to the flame 9, resulting in a change in the spectrum of light emitted by the flame.

[0056] Light sensor 21 generates an analogue sensor signal 12 based on light irradiated onto a photodiode of the sensor 21, said sensor signal 12 being fed into the control system 1, which is represented by method step 404.

[0057] In method step 405, the control system 1 automatically assesses whether the intended change of the characteristic of the flame 9 is reflected by the sensor signal 12. The control system 1 can perform this task for example by assessing whether a change in the output signal 12 sufficiently correlates in time with the intended changing of the operation parameter 32 of the combustion appliance 3 or with the moment in time when the control signal 11 was sent to the burner. In addition, or alternatively, the control system 1 can perform this task also by assessing whether a change in the output signal 12 sufficiently correlates in a signal amplitude with an expected amplitude of the sensor signal 12 corresponding to the change of the intended change in the spectrum of light emitted by the flame.

[0058] In case the sensor signal 12 sufficiently correlates with the expected change the assessment was positive, indicating that the flame sensor configuration 2 is properly monitoring the flame 9. Consequently, the method 400 proceeds with method step 406. That is, the method waits for a predetermined period and/or amount of time. Afterwards, the test of the sensor configuration 2 reiterates and starts again with method step 402.

[0059] In case in method step 405 the control system does not find a sufficient correlation of a change in the sensor signal 12 with an expected change representing the expected change of the characteristic of the flame 9, this is an indication, that the flame sensor configuration is not working properly. Consequently, the method 400 proceeds with method step 407 by taking appropriate measures like stopping the supply of fuel to the burner 32 and/or generating an alarm signal.

[0060] Figure 5 shows schematically a block diagram of an architecture of the control system 1 according to an embodiment of the invention. The control system 1 comprises a processor 42, an accessible memory 43, and one or more interfaces 44.

[0061] The one or more interfaces 44 are connectable to the flame sensor configuration 2, and to the burner 31. The accessible memory 2 comprises a computer program 45 comprising instructions to cause the control system 1 to execute the steps of the method described in accordance with FIG. 4.

[0062] The computer program thus comprises instructions to cause the processor 42 to generate control signal 11 causing the combustion appliance 3 to change an operation parameter 32 of the burner 31 resulting in a change of a characteristic 91 of the flame 9. The instructions of the computer program further cause the processor to process the sensor signal 12 received from the flame sensor 21 via the interface 44. The processing of the sensor signal 12 comprises assessing whether the change of the characteristic 91 of the flame 9 is detected by the flame sensor configuration 2.

[0063] Figure 6 shows a graph of a simulation of a control signal 11, and sensor signal 12 over time in arbitrary units (a.u.) from 0 a.u to 300 a.u. Time is depicted on the abscissa, amplitudes are depicted on the ordinate. In the simulation every a.u. on the time axis corresponds to a simulated creation of a control signal 11 and a simulated measurement of the sensor signal 12.

[0064] The value of the control signal 11 is 0 (zero) from time 0 a.u. to 100 a.u. Value zero for the amplitude of the control signal 11 causes the burner 31 not to change the operation parameter 32 of combustion appliance 3, such that the burner 31 will operate according to the conditions set manually or automatically by the combustion control system which can be integrated into the control system 1. During this time interval, the burner 31 is supplied with a substantially constant amount of fuel or combustion air or fuel-air-mixture, however, there can be arbitrary fluctuations in the combustion process, which is represented by fluctuations in the sensor signal 12.

[0065] From time 101 a.u. to time 129 a.u., the value of the control signal 11 is switched by the control system 1 to an amplitude value of 1. Value 1 for the amplitude of the control signal 11 causes the burner 31 to change the operation parameter 32 of the combustion appliance, such that the flame 9 is supplied with a different amount fuel or combustion air or fuel-air-mixture than during the time interval from 0 to 100 a.u. Also, during this time interval, the burner 31 is supplied with a substantially constant amount of fuel or combustion air or fuel-air-mixture.

[0066] From time 130 a.u until 300 a.u. the value of the control signal is switched again to 0.

[0067] The change in the operation parameter 32 is reflected in the values of the amplitude of the sensor signal 12. From time 101 a.u. on, the amplitude of the sensor signal 12 drops and stays reduced until 129 a.u compared to the amplitude values it had during the time intervals 0-100 a.u. and 130-300 a.u.

[0068] Figure 7 shows a processing of the sensor signal 12. The processing includes generating a filtered signal 13 of the sensor signal 12 by creating mean and median values of five subsequent values of signal 12. Based on the filtered signal 13 it is then assessed that the change of the characteristic of the flame was detected based on the correlation of the amplitude drop in the time interval from 101 a.u. to 129 a.u. Line 76 visualizes the level of signal 13 before the sensor test, while line 77 visualizes the level of signal 13 that has dropped due to the sensor test during time interval 101-129 a.u. The difference in the two levels 76 and 77 as well as the correlation of signals 12 and 13 with control signal 11 indicates proper working of the sensor configuration 2.

[0069] Figures 8 and 9 show the graphs of Figures 6 and 7 over a longer time span including several periodically carried out sensor tests at 100 a.u., 400 a.u, 700 a.u. Line 78 represents the sensor test result, i.e. the assessment whether the intended change of the characteristic of the flame is detected by the flame sensor configuration or not. The assessment was performed based on the processed signal 12 (thus signals 76, 77), and the control signal 11. As is visible in Fig 9, after the first sensor test, the test result signal 78 has a value of 1 (true), indicating that all sensor tests successfully indicated that the flame sensor configuration is properly operating. Due to the simulation, the test result signal 78 is 0 (false) before the first test. However, in a non-simulated setup, the test result signal could also be initially set to value of 1 (true).

[0070] A combustion appliance 3 is envisaged, wherein the changing of the operation parameter of the combustion appliance 3 is at least one of:

a changing of an amount of fuel applied to the flame 9,
a changing of an amount of combustion air applied to the flame 9.

[0071] A combustion appliance 3 is envisaged, wherein the automated change of the operation parameter of the combustion appliance 3 is at least one of:

a changing of an amount of fuel applied to the flame 9,
a changing of an amount of combustion air applied to the flame 9.

[0072] The instant disclosure also pertains to a method, wherein the changing of the operation parameter of the combustion appliance 3 is performed by at least one of:

changing an amount of fuel applied to the flame 9,
changing an amount of combustion air applied to the flame 9.

[0073] The instant disclosure also pertains to a method, wherein the automated change of the operation parameter of the combustion appliance 3 is performed by at least one of:

changing an amount of fuel applied to the flame 9, changing an amount of combustion air applied to the flame 9.

[0074] In other words, the present disclosure deals with a control system (1) for automatically testing a flame sensor configuration (2) for monitoring the functioning of a combustion appliance (3) by monitoring a flame (9) of the combustion appliance (3), the control system (1) being adapted for:

- Processing a control signal (11) related to an intended causing of the combustion appliance (3) to change an operation parameter (32) resulting in a change of a characteristic (91) of the flame (9);
- Processing a sensor signal (12) received from the flame sensor configuration (2), said sensor signal (12) carrying an information detected by the flame sensor configuration (2) about the characteristic of the flame, wherein said processing of the sensor signal (12) comprises assessing whether the intended change of the characteristic (91) of the flame (9) is detected by the flame sensor configuration (2) .

[0075] The present disclosure also deals with any of the aforementioned control systems (1), wherein the sensor signal (12) is an analogue signal.

[0076] The present disclosure still deals with any of the aforementioned control systems (1), wherein the control signal (11) is related to an intended causing of the combustion appliance to change an operation parameter during continuous operation of the flame.

[0077] The instant disclosure also deals with a flame sensor configuration (2) for monitoring the functioning of a combustion appliance (3) comprising any of the aforementioned control systems (1) and comprising a sensor (21) for generating the sensor signal (12) based on detecting the characteristic of the flame (9).

[0078] The instant disclosure also deals with any of the aforementioned flame sensor configurations (2), wherein the sensor (21) is a light sensor adapted and arranged for detecting light emitted by the flame (9), and the change of the characteristic of the flame (9) is preferably a change in the signature of light emitted by the flame (9) and/or a change of the spectrum of light emitted by the flame (9) and/or a change of an intensity of light emitted by the flame (9) and/or a change of a spectral intensity of light emitted by the flame (9).

[0079] The instant disclosure also deals with a combustion appliance (3) comprising a burner (31), and any of the aforementioned flame sensor configurations (2), wherein the burner (31) is configured to generate the flame (9), preferably by burning a fluid fuel.

[0080] The instant disclosure still deals with any of the aforementioned combustion appliances (3), wherein the changing of the operation parameter of the combustion appliance (3) is a changing of an amount of fuel applied to the flame (9) and/or a changing of an amount of combustion air applied to the flame (9).

[0081] The present disclosure also deals with a method for automatically testing a flame sensor configuration (2),

wherein the flame sensor configuration (2) is adapted for monitoring the functioning of a combustion appliance (3) by monitoring a flame (9) of the combustion appliance (3),
the method comprising the steps of:

- Automatically changing (403) an operation parameter of the combustion appliance (3) intended to result in a change of a characteristic of the flame (9);
- Automatically assessing (408) whether the intended change of the characteristic of the flame (9) is detected by the flame sensor configuration (2).

[0082] The instant disclosure still deals with any of the aforementioned methods, wherein the combustion appliance (3) is adapted for burning a fluid fuel in order to produce the flame (9).

[0083] The instant disclosure further deals with any of the aforementioned methods, wherein the flame sensor configuration (2) is a light sensor configuration comprising at least one light sensor adapted and arranged for detecting light emitted by the flame (9), and the changed characteristic of the flame (9) is preferably a change of the signature of light emitted by the flame (9) and/or a change of the spectrum of light emitted by the flame (9) and/or a change of an intensity of light emitted by the flame (9) and/or a change of a spectral intensity of light emitted by the flame (9).

[0084] The instant disclosure yet further deals with any of the aforementioned methods, wherein the flame sensor configuration (2) comprises a light sensor with an analogue signal output which is used for said testing of the flame sensor configuration (2).

[0085] The present disclosure yet further deals with any of the aforementioned methods, wherein the testing of the flame (9) is performed during continuous operation of the combustion appliance (3).

[0086] The present disclosure also deals with any of the aforementioned methods, wherein the changing of the operation parameter of the combustion appliance (3) is performed by changing an amount of fuel applied to the flame (9) and/or by changing an amount of combustion air applied to the flame (9).

[0087] The instant disclosure still pertains to a computer program comprising instructions to cause a control system (1) of the instant disclosure to execute the steps of a method described herein.

[0088] The instant disclosure still pertains to a computer-readable medium having stored thereon any of the aforementioned computer programs.

[0089] The present disclosure is still directed to a flame sensor configuration (2) for monitoring the functioning of a combustion appliance (3), the flame sensor configuration (2) comprising a control system (1) for automatically testing a flame sensor configuration (2) for monitoring the functioning of the combustion appliance (3) by monitoring a flame (9) of the combustion appliance (3), the control system (1) being adapted for:

- Processing a control signal (11) related to an intended causing of the combustion appliance (3) to change an operation parameter (32) resulting in a change of a characteristic (91) of the flame (9);
- Processing a sensor signal (12) received from the flame sensor configuration (2), said sensor signal (12) carrying an information detected by the flame sensor configuration (2) about the characteristic of the flame, wherein said processing of the sensor signal (12) comprises assessing whether the intended change of the characteristic (91) of the flame (9) is detected by the flame sensor configuration (2);

  the flame sensor configuration (2) comprising a sensor (21) for generating the sensor signal (12) based on detecting the characteristic of the flame (9);
  wherein the sensor (21) is a light sensor adapted and arranged for detecting light emitted by the flame (9), and the change of the characteristic of the flame (9) comprises at least one of:

    a change in the signature of light emitted by the flame (9),
    a change of the spectrum of light emitted by the flame (9),
    a change of an intensity of light emitted by the flame (9),
    a change of a spectral intensity of light emitted by the flame (9) .

[0090] The present disclosure is still directed to any of the aforementioned flame sensor configurations (2), wherein the sensor signal (12) is an analogue signal.

[0091] The present disclosure is still further directed to any of the aforementioned flame sensor configurations (2), wherein the control signal (11) is related to an intended causing of the combustion appliance to change an operation parameter during continuous operation of the flame.

[0092] The present disclosure is also still directed to a combustion appliance (3) comprising a burner (31), and a flame sensor configuration (2) as described herein, wherein the burner (31) is configured to generate the flame (9), preferably by burning a fluid fuel.

[0093] The present disclosure is also still directed to any of the aforementioned combustion appliances (3), wherein the changing of the operation parameter of the combustion appliance (3) is a changing of an amount of fuel applied to the flame (9) and/or a changing of an amount of combustion air applied to the flame (9).

[0094] The instant disclosure is still directed to a method for automatically testing a flame sensor configuration (2),

  wherein the flame sensor configuration (2) is adapted for monitoring the functioning of a combustion appliance (3) by monitoring a flame (9) of the combustion appliance (3),
  wherein the flame sensor configuration (2) is a light sensor configuration comprising at least one light sensor adapted and arranged for detecting light emitted by the flame (9), and a change of the characteristic of the flame (9) comprises at least one of: a change of the signature of light emitted by the flame (9),
  a change of the spectrum of light emitted by the flame (9),
  a change of an intensity of light emitted by the flame (9),
  a change of a spectral intensity of light emitted by the flame (9); the method comprising the steps of:

  - Automatically changing (403) an operation parameter of the combustion appliance (3) intended to result in the change of the characteristic of the flame (9);
  - Automatically assessing (408) whether the intended change of the characteristic of the flame (9) is detected by the flame sensor configuration (2).

[0095] The instant disclosure is still directed to any of the aforementioned methods, wherein the combustion appliance (3) is adapted for burning a fluid fuel in order to produce the flame (9).

[0096] The present disclosure is still directed to any of the aforementioned methods, wherein the flame sensor configuration (2) comprises a light sensor with an analogue signal output which is used for said testing of the flame sensor configuration (2).

[0097] The present disclosure is also directed to any of the aforementioned methods, wherein the testing of the flame (9) is performed during continuous operation of the combustion appliance (3).

[0098] The present disclosure is still further directed to any of the aforementioned methods, wherein the changing of the operation parameter of the combustion appliance (3) is performed by changing an amount of fuel applied to the flame (9) and/or by changing an amount of combustion air applied to the flame (9).

[0099] The present disclosure is yet further directed a computer program comprising instructions to cause a control system (1) of a flame sensor configuration (2) as explained in detail before to execute the steps of the aforementioned methods.

[0100] The present disclosure is also directed a computer-readable medium having stored thereon any of the aforementioned computer program.

[0101] It should be understood that the foregoing relates only to certain embodiments of the invention and that numerous changes may be made therein without departing the scope of the invention as defined by the following claims. It should also be understood that the invention is not restricted to the illustrated embodiments and that various modifications can be made within the scope of the following claims.

Claims

1. Flame sensor configuration (2) for monitoring the functioning of a combustion appliance (3), the flame sensor configuration (2) comprising a control system (1) for automatically testing a flame sensor configuration (2) for monitoring the functioning of the combustion appliance (3) by monitoring a flame (9) of the combustion appliance (3), the control system (1) being adapted for:

    • Processing a control signal (11) related to an intended causing of the combustion appliance (3) to change an operation parameter (32) resulting in a change of a characteristic (91) of the flame (9);
    • Processing a sensor signal (12) received from the flame sensor configuration (2), said sensor signal (12) carrying an information detected by the flame sensor configuration (2) about the characteristic of the flame, wherein said processing of the sensor signal (12) comprises assessing whether the intended change of the characteristic (91) of the flame (9) is detected by the flame sensor configuration (2);
    the flame sensor configuration (2) comprising a sensor (21) for generating the sensor signal (12) based on detecting the characteristic of the flame (9);
    wherein the sensor (21) is a light sensor adapted and arranged for detecting light emitted by the flame (9), and the change of the characteristic of the flame (9) comprises at least one of:

        a change in the signature of light emitted by the flame (9),
        a change of the spectrum of light emitted by the flame (9),
        a change of an intensity of light emitted by the flame (9),
        a change of a spectral intensity of light emitted by the flame (9) .

2. The flame sensor configuration (2) according to claim 1, wherein the sensor signal (12) is an analogue signal.

3. The flame sensor configuration (2) according to any of the preceding claims, wherein the control signal (11) is related to an intended causing of the combustion appliance to change an operation parameter during continuous operation of the flame.

4. Combustion appliance (3) comprising a burner (31), and the flame sensor configuration (2) according to any of the claims 1 to 3, wherein the burner (31) is configured to generate the flame (9), preferably by burning a fluid fuel.

5. The combustion appliance (3) according to claim 4, wherein the changing of the operation parameter of the combustion appliance (3) is a changing of an amount of fuel applied to the flame (9) and/or a changing of an amount of combustion air applied to the flame (9).

6. Method for automatically testing a flame sensor configuration (2), wherein the flame sensor configuration (2) is adapted for monitoring the functioning of a combustion appliance (3) by monitoring a flame (9) of the combustion appliance (3),
wherein the flame sensor configuration (2) is a light sensor configuration comprising at least one light sensor adapted and arranged for detecting light emitted by the flame (9), and a change of the characteristic of the flame (9) comprises at least one of:

    a change of the signature of light emitted by the flame (9),
    a change of the spectrum of light emitted by the flame (9),
    a change of an intensity of light emitted by the flame (9),
    a change of a spectral intensity of light emitted by the flame (9); the method comprising the steps of:

        • Automatically changing (403) an operation parameter of the combustion appliance (3) intended to result in the change of the characteristic of the flame (9);
        • Automatically assessing (408) whether the intended change of the characteristic of the flame (9) is detected by the flame sensor configuration (2).

7. The method according to claim 6, wherein the combustion appliance (3) is adapted for burning a fluid fuel in order to produce the flame (9).

8. The method according to any of the claims 6 to 7, wherein the flame sensor configuration (2) comprises a light sensor with an analogue signal output

which is used for said testing of the flame sensor configuration (2).

9. The method according to any of the claims 6 to 8, wherein the testing of the flame (9) is performed during continuous operation of the combustion appliance (3).

10. The method according to any of the claims 6 to 9, wherein the changing of the operation parameter of the combustion appliance (3) is performed by changing an amount of fuel applied to the flame (9) and/or by changing an amount of combustion air applied to the flame (9).

11. A computer program comprising instructions to cause the control system (1) of the flame sensor configuration (2) of claim 1 to execute the steps of the method of any of the claims 6 to 10.

12. A computer-readable medium having stored thereon the computer program of claim 11.

FIG. 1

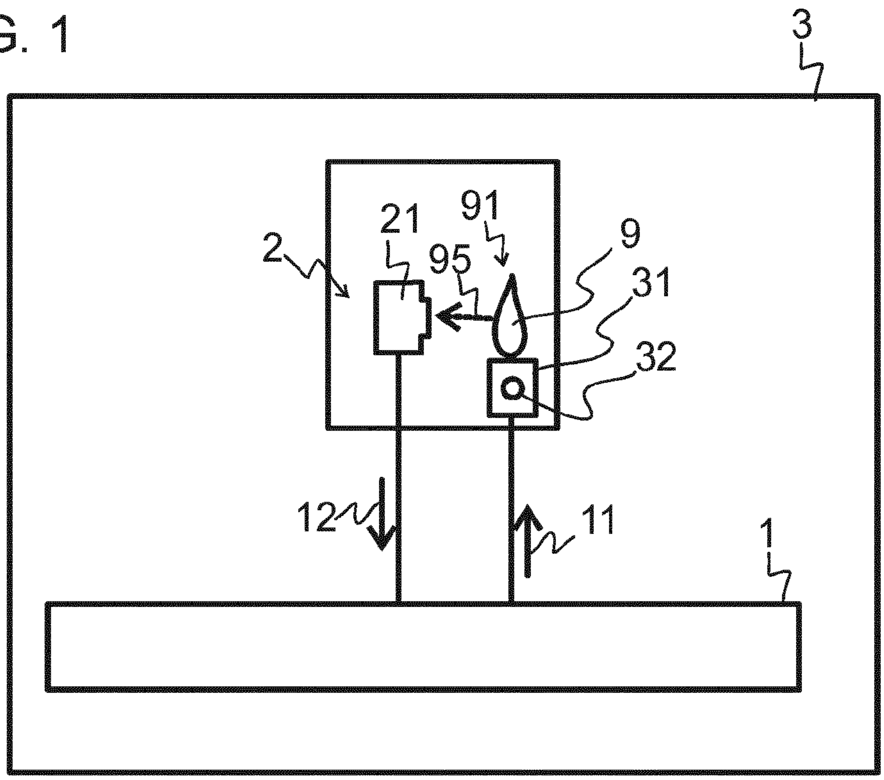


FIG. 2

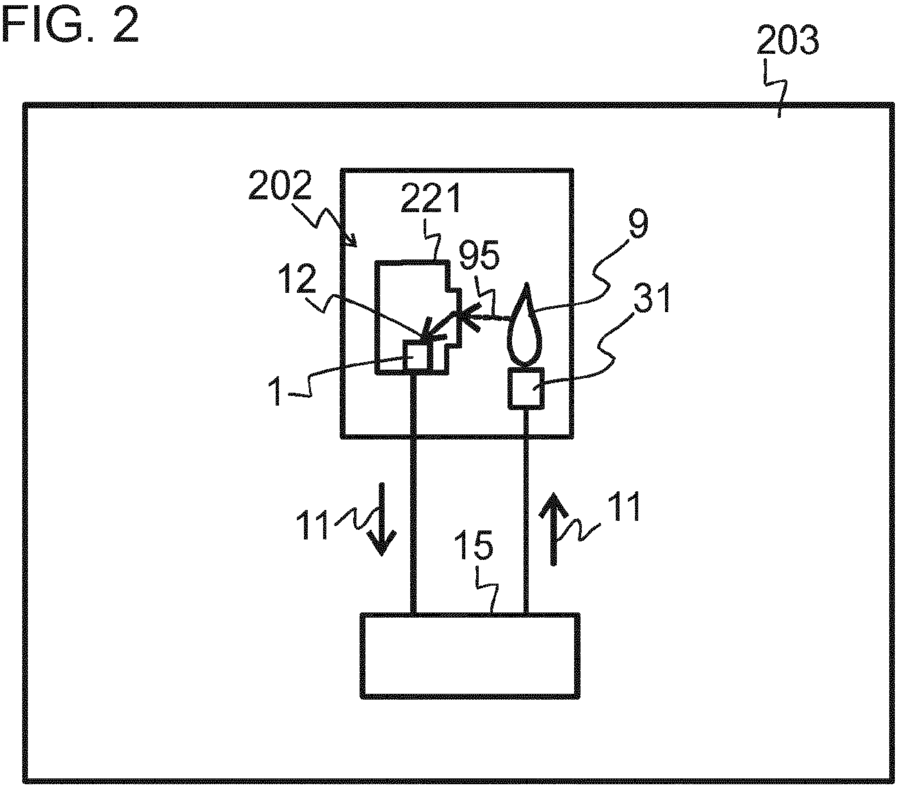


FIG. 3

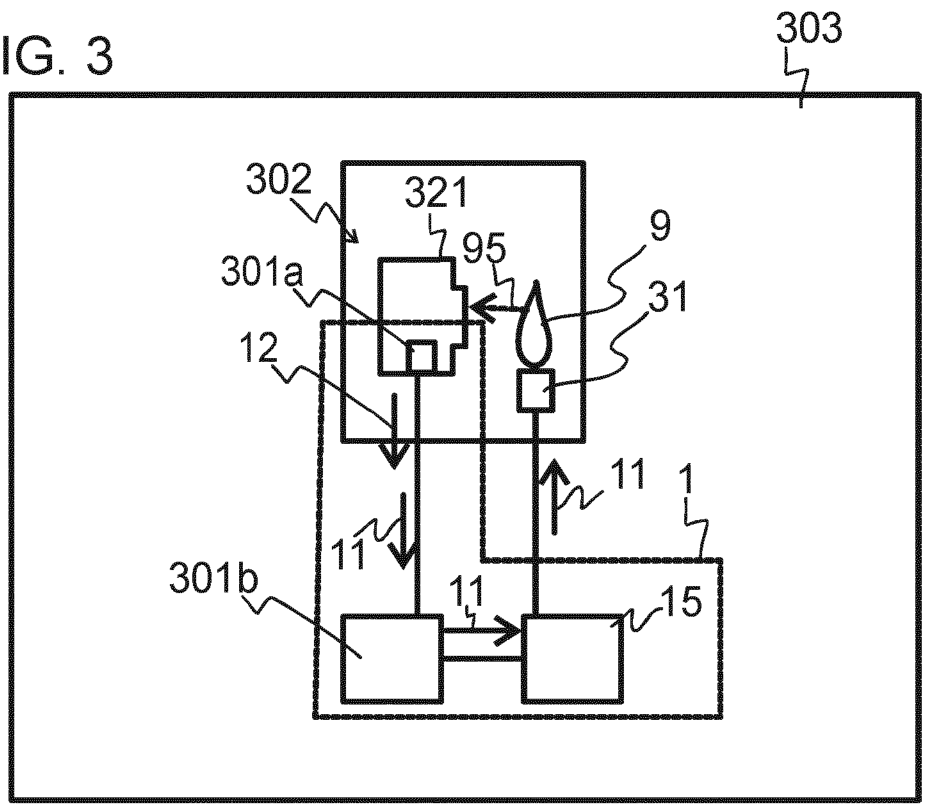


FIG. 4

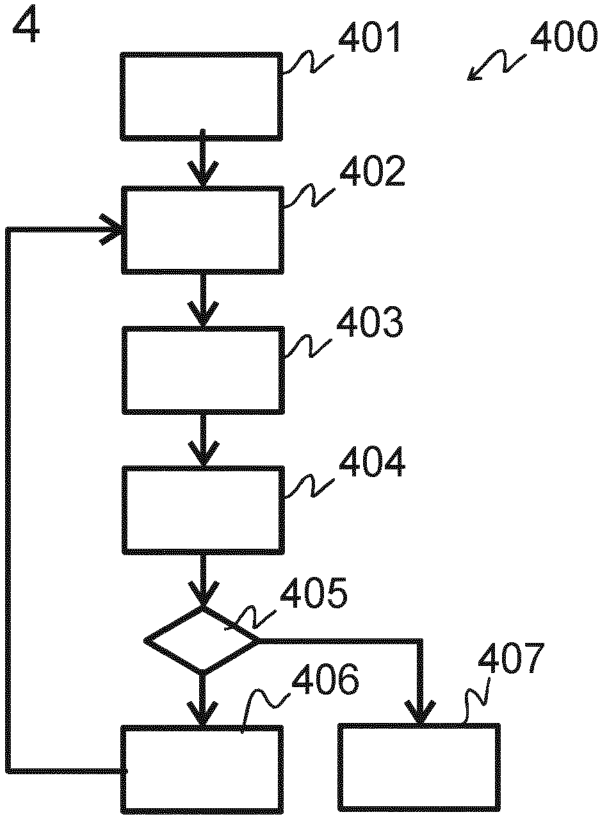


FIG. 5

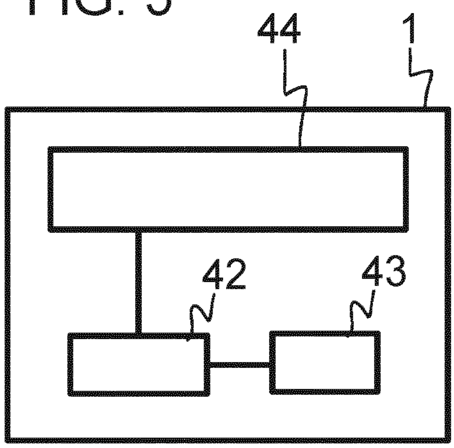
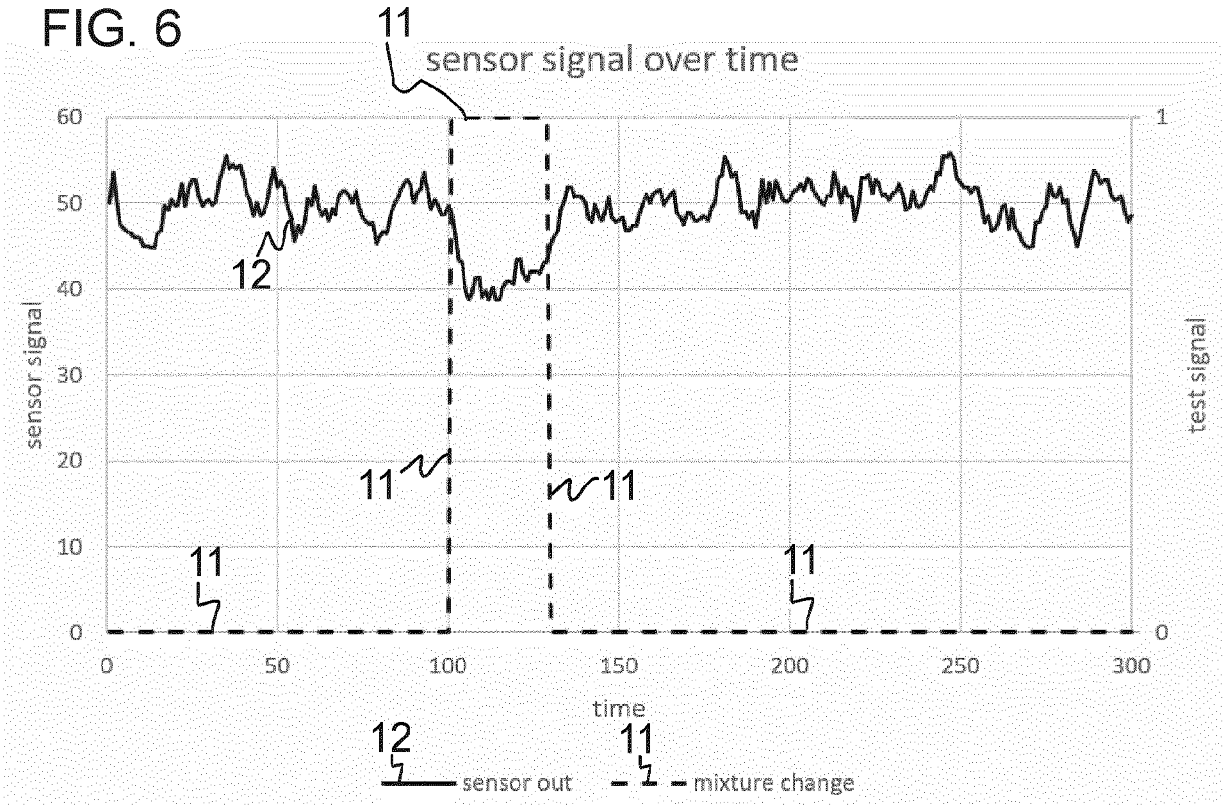
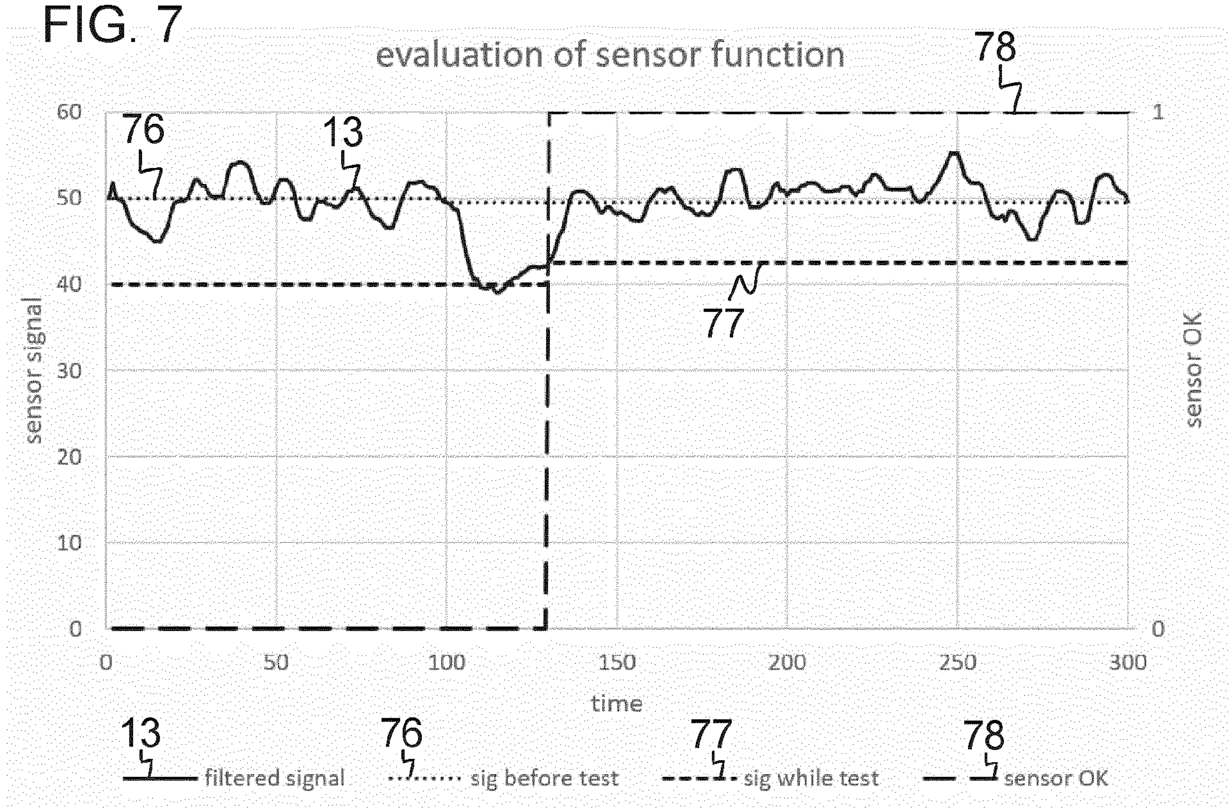


FIG. 6



sensor signal over time
11
12
sensor signal
test signal
60
50
40
30
20
10
0
1
0
0
50
100
150
200
250
300
time
sensor out
mixture change

FIG. 7



evaluation of sensor function
76
13
77
78
sensor signal
sensor OK
60
50
40
30
20
10
0
1
0
0
50
100
150
200
250
300
time
filtered signal
sig before test
sig while test
sensor OK

FIG. 8

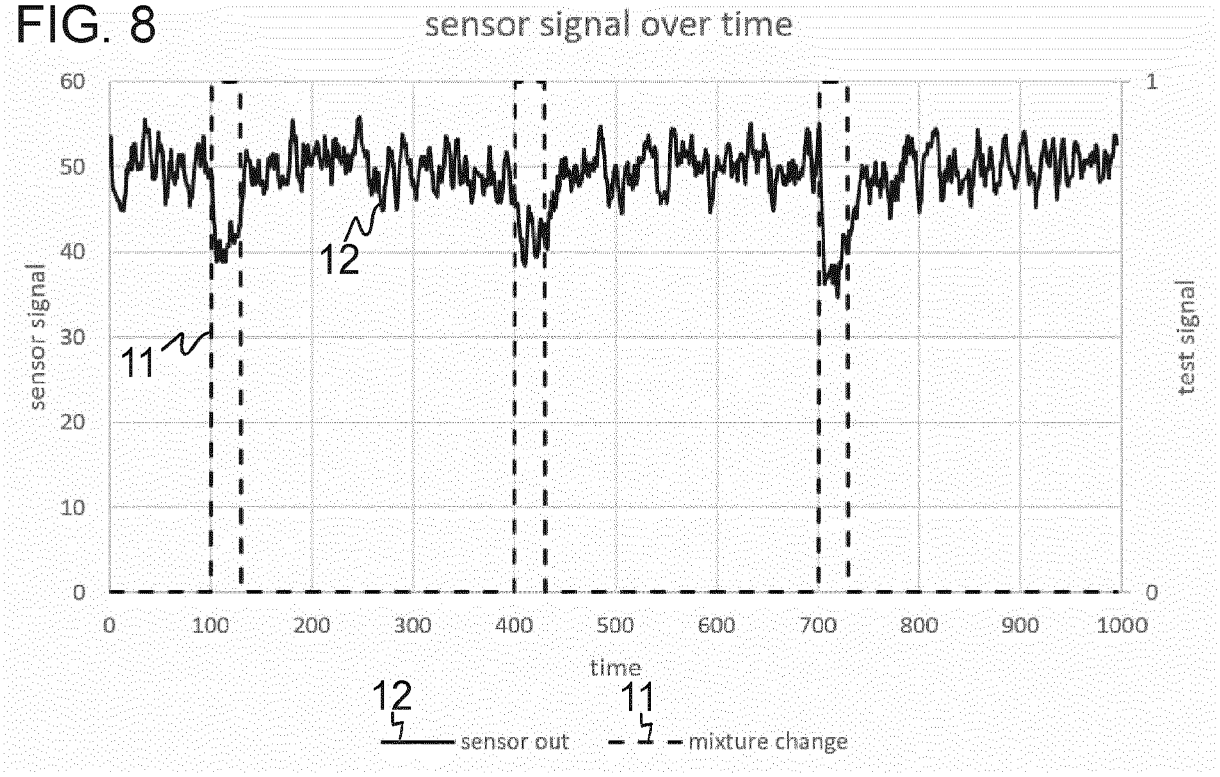
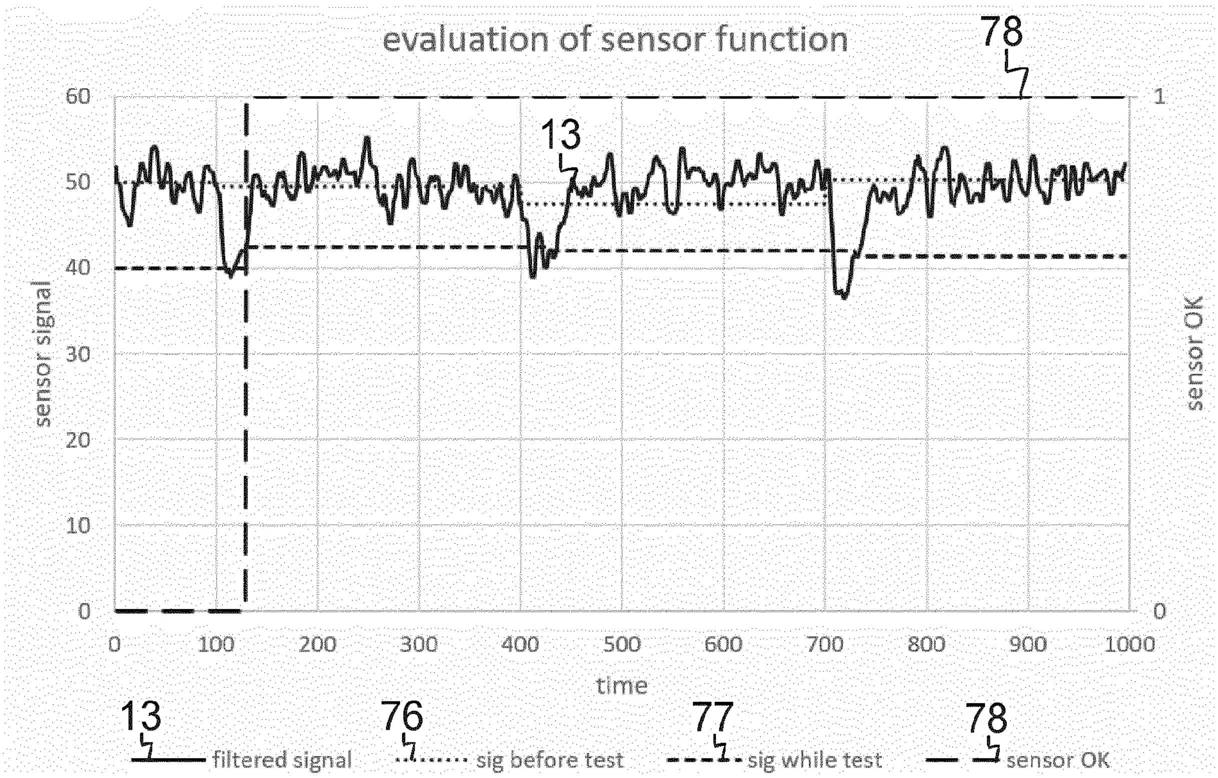

sensor signal over time
60
50
40
30
20
10
0
sensor signal
1
0
test signal
0
100
200
300
400
500
600
700
800
900
1000
time
11
12
sensor out
mixture change

FIG. 9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78
13
60
50
40
30
20
10
0
sensor signal
1
0
sensor OK
0
100
200
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400
500
600
700
800
900
1000
time
13
filtered signal
76
sig before test
77
sig while test
78
sensor OK

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 6356

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
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07-05-2024

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