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(54) **A METHOD AND DEVICE FOR CONTROLLING THE QUALITY OF COMBUSTION IN A BURNER**

VERFAHREN UND VORRICHTUNG ZUR KONTROLLE DER VERBRENNUNGSQUALITÄT IN
EINEM BRENNER

PROCÉDÉ ET DISPOSITIF PERMETTANT DE CONTRÔLER LA QUALITÉ DE LA COMBUSTION
DANS UN BRÛLEUR

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Description

[0001] The present invention regards a method and a device for controlling the quality of combustion in a burner in general, especially for use in atmospheric boilers with closed chamber of so-called "C"-type.

[0002] As is known, for controlling the combustive air flow rate of C-type atmospheric boilers, an air pressure switch is used which requires the prearrangement of mechanical securing components to the boiler, the electrical connection with a circuit board, the pneumatic connection with the fan, and a Venturi tube for the fan. As is known, problems of condensate formation occur in the Venturi apparatus, which compromise its functioning.

[0003] On the other hand, an air pressure switch in an atmospheric boiler, once a predetermined air pressure threshold is reached, reacts in a manner entirely independent of the flow rate of the combustible gas.

[0004] Hence, with conventional atmospheric boilers, problems often occur that are connected with the generation of signals, so-called "false signals", not in keeping with a specific actual situation.

[0005] A system of fault detection in a warm air furnace is disclosed in US-2005/0284463 and comprises a sensing circuit designed to measure a level of current which depends on the amount of AC loading (e.g. the ignition element, the fan, the inducer and/or other loadings, such as a low voltage transformer or the like) applied thereto. In such known system the measured level of current consumption is measured at different times during the operation sequence of the furnace and is compared with an expected value. If the measured current level exceeds the expected value by a threshold amount, a fault in the furnace can be detected and an indication of at least one warm air furnace component that is most likely to have caused the fault can be provided. The measured current level is a peak value that requires to be offset by a correction factor correlated to voltage variations, such variations being caused by power fluctuations or noise that naturally occur in a power delivering system and are detectable by a suitable voltage sensing circuit. Such a system has the inconvenience of not being always sufficiently responsive to changes in the working conditions of the warm air furnace components, and thus it reacts too slowly to malfunctions of the system components.

[0006] US-5 906 440 teaches a method of controlling an induced fan for use in gas furnaces. Such a method requires measurement of the current absorbed by the fan and the electromotive force produced thereby. The flow rate of the combustive air is then controlled by varying the fan speed in response to the fan measured current and electromotive force. The drawback of this method is that the control of the fan speed is quite complicated to be carried out.

[0007] In EP-1 331 444 a method of controlling a gas burner is disclosed. A sensor means at the exhaust duct of the gas burner monitors the carbon monoxide concen-

tration in the exhaust gas and generates a respective electrical signal. A calibration process can be triggered wherein the gas/air mixture is varied until the exhaust sensor signal matches a given threshold value. In order to do so the fan speed can be varied. Another method of controlling a gas burner is disclosed by US-2002/048737 A.

[0008] The main object of the present invention is that of providing a method and a device for controlling the quality of combustion in a burner, which is reliable and which can be used in an effective manner even in different functioning conditions of the burner, especially if employed in atmospheric boilers with closed chamber of so-called "C"-type.

[0009] Another object of the present invention is that the method and the device mentioned above are simple to make and maintain.

[0010] Another object of the present invention is that of providing a device for controlling a burner which can be calibrated as a function of the real functioning conditions of the burner.

[0011] Further aspects and advantages of the present invention will better appear from the following detailed description of specific embodiments thereof, such description being made with reference to the accompanying drawings, in which:

- Figure 1 is a block diagram of a device for controlling a gas burner incorporated in an atmospheric boiler with closed chamber according to the present invention;
- Figure 2 shows a diagram showing characterization curves of a suction fan for supplying combustive air to the burner of Fig. 1 ;
- Figure 3 is a flow diagram which illustrates the functioning of the device according to the present invention;
- Figure 4 shows a curve which represents the ratio between the ionization current and the excess air index in the burner of Fig. 1 ;
- Figure 5 shows curves representative of the ratio between the combustible gas flow rate and the ionization current in the burner of Fig. 1 ;
- Figure 6 is a flow diagram which illustrates the steps for calibrating the burner of Fig. 1 ; and
- Figure 7 is a flow diagram which illustrates the steps for monitoring the ionization current in the burner of Fig.1.

[0012] In the accompanying drawings, equivalent or similar parts or components were marked with the same reference numbers.

- First, with reference to Fig. 1 , a control device 1 according to the present invention is schematically illustrated. Such device is applied to a burner BR, e.g. a gas burner for use in an atmospheric boiler CA, so-called of type C, i.e. with closed combustion

chamber CC that can be supplied with forced combustive air by means of combustive air supply means, such as suction means, typically an electric fan F driven by a motor, e.g. an electric motor (not shown and of any suitable type), with fixed speed. The burner BR is supplied both with combustive fluid, preferably a combustive gas through a supply duct DT1 interceptable by an electric adjustment valve EV, and with combustive air through a combustive air supply duct DT2. Associated with the burner is a duct, e.g. with heating coil HC mounted in the combustion chamber CC of the boiler CA, in which water to be heated is made to flow through. The fan F is advantageously arranged in the upper zone of the combustion chamber CC, from which it sucks the combustion fumes and discharges them outside through a duct DT3; the fan thus creates reduced pressure in the combustion chamber CC which is open at the bottom due to the presence of a bell-shaped, insulating partition wall PI for isolating the combustion chamber. Due to such reduced pressure, combustive air is sent through the duct DT2 and enters the top of the boiler where it contributes to cooling the fan F and is pre-heated before entering the lower part of the combustion chamber by impacting with the burner BR. Preferably, a combustion fumes analyzer FA is also provided for, placed in the duct DT3, which sends detected concentration value signals to a display DS.

[0013] The device 1 is composed of a control circuit board 2 provided with a microprocessor 3, preferably, formed by two separate functional units: one 4 for acquiring and processing signals and another for managing and adjusting 6, particularly intended for controlling possible variations of the modulation level (opening/closing) of the electric valve EV and, consequently, the thermal flow rate of the burner BR, by sending suitable output control signals via cable or wireless network 5. Preferably, a signal can be provided for that is designed to open/close the electric valve, and another signal can be provided that, when the electric valve is open, determines the degree of opening of the electric valve itself.

[0014] The device 1 also comprises signal converter units or circuits 7 and 8, which receive, in input, the output control signals from the microprocessor 3, and in particular from the management and adjustment unit 6 and directed towards the electric valve EV, and they convert them in order to determine the limit thresholds, as explained below. The first converter circuit 7 is set to convert the acquired signals into corresponding threshold values correlated with respective flame ionization current values and to send them, in input, to a first comparator circuit or means 9, while the second converter circuit 8 is set to convert the output signals acquired in input from the microprocessor into respective threshold values of supply voltage V of the fan and of current AC absorbed by the motor of the electric fan F and to transmit them in input

to a second 10 and a third 11 comparator circuit or means.

[0015] The device 1 also comprises sensor means, such as an electrode 12 of any suitable type, suitably arranged in the combustion chamber CC of the burner BR so as to be immersed in the flame after the lighting of the burner itself; it is thus able to detect the actual value of the ionization current of the flame FI in the combustion chamber and to produce output electrical signals. The electrode 12 is in external communication with a transducer circuit or means 13 (typically a microammeter or very sensitive ammeter of any suitable type), which is set to transform the thermal stresses on the electrode 12 into corresponding electrical signals; such signals are sent in input to the first comparator circuit or means 9. The comparator circuit 9 will compare, in use, the signals received in input coming from the transducer circuit 13, representative of the actual ionization current of the flame FI, with threshold signals coming from the converter circuit 7 in order to produce corresponding output signals to be transmitted in input to the acquisition and processing unit 4.

[0016] Preferably, the voltage applied on the electrode can be between 170 Volt AC and 1000 Volt AC, such that the detection of flame ionization current is not affected by the aging of the electrode or by dirt accumulated on the electrode itself, since the measuring error deriving from such phenomena would not be perceptible by the measurement instrument.

[0017] Making up part of the device 1 are also two detection or measurement units or means of any suitable type in electrical connection with the motor of the fan F: one 14 set to measure the supply voltage V of the motor of the fan and the other 15 set to measure the current absorbed AC by the same motor. The measurement units 14 and 15, in use, emit output signals which are applied in input to a respective comparator circuit or means 10 and 11. The comparator circuit 10 is set to carry out the comparison between supply voltage signals V coming from the measurement unit 14 and threshold signals received from the converter circuit 8 in order to produce output signals that are applied to an input of the acquisition and processing unit 4, whereas the comparator circuit 11 compares, in use, absorbed current signals AC coming from the measurement unit 15 in order to produce output signals which are applied to another input of the acquisition and processing unit 4.

[0018] According to the present invention, the detected absorbed current can be alternating current or direct current. More particularly, it is possible: a) to detect the alternating current and, e. g. by means of a current transformer, also obtain direct current; b) to detect the alternating current by means of a shunt device; or c) to detect the alternating current and the displacement between current and voltage.

[0019] When the supply voltage V of the motor of the fan F and the current absorbed by the same motor are alternating electrical signals, their effective values are advantageously calculated. The time cycle considered

for this calculation is half the cycle of the mains frequency (e.g. 50 Hz).

[0020] More particularly, the supply voltage V of the motor of the fan F is processed by a voltage divider block (not illustrated in the drawings) so that the output signal of the voltage divider block is a voltage V_{out} proportional to the supply voltage V of the fan motor. V_{out} is then converted into a digital signal by an A/D converter (also not illustrated in the drawings) and its effective value V_{eff} is determined.

[0021] In so far as the absorbed current signal is concerned, the latter is proportional to the voltage drop at a shunt device that is connected in series with the fan motor. The current signal is converted into a digital signal by an A/D converter and then the effective value I_{eff} is calculated.

[0022] It will be noted that the effective current value I_{eff} thus obtained depends on the motor winding temperature and the frequency. Such a dependence is reduced to a negligible effect by correcting I_{eff} with respective correction factors. Such correction factors are defined during the "characterization" procedure of the fan F which is carried out at a design stage.

[0023] The "characterization" procedure of fan F comprises the steps of determining a specific correction factor for any temperature that the motor winding can reach, and a correction factor for any frequency.

[0024] More particularly, the motor windings temperature can be obtained by applying a temperature sensor means directly to the motor winding or, for example, by measuring the electrical resistance of the winding. In the latter case, a known voltage can be applied to the series formed by the motor winding and a known resistance. An electrical divider is thus obtained and, by measuring the voltage drop at the winding, the resistance value of the winding can be derived. Given the resistance, the temperature of the motor winding can be calculated in a known way.

[0025] The frequency correction factor can be stored in a table or calculated in any suitable way starting from the number of samples used for calculating the effective current and voltage values.

[0026] If the acquisition and processing unit 4 detects an irregular functioning condition, i.e. if, on the basis of the signals received from one of the comparator circuits 9, 10 or 11, it detects that the flame ionization current FI or the supply voltage V of the fan F or the current absorbed AC from the motor of the fan F exceeds the respective working threshold value established by one of the converter circuits 7, 8, it produces an output signal which is applied in input to the management and adjustment unit 6, which will produce a corresponding output control signal to be sent to the electric valve EV .

[0027] Such control signal can be a complete closure signal of the electric valve EV , so as to stop the functioning of the burner, or it can be a modulation signal of the opening/closing of the electric valve or, alternatively, it can also be a control signal for an acoustic or light alarm

device, or for a remote warning device of any suitable type.

[0028] Methods for controlling the quality of combustion in a burner according to the present invention will be described in more detail below. Such methods are preferably carried out by the device 1, typically with the use of a gas burner BR for atmospheric boiler CA of type C , i.e. with closed combustion chamber, with forced suction of combustive air by means of fixed-speed electric fan F .

[0029] One such evaluation is carried out by means of:

- the monitoring or calculation of the supply voltage V and the current absorbed AC by the motor of the fan F ; and/or
- the monitoring or calculation of the ionization current of the flame FI of the burner BR .

[0030] Preferably, a so-called "safety" cycle is initially carried out, aimed to verify the correct functioning of the motor of the fan F and of the fan F itself while the burner is turned off. A prewashing step is achieved of the combustion chamber CC of the burner BR , in order to avoid that an unburned gas saturation situation occurs at the time of burner lighting.

[0031] The verification of the correct functioning of the electric fan F is grounded on the correlation that exists between the value of the supply voltage V of the motor of the fan F and the value of the current absorbed AC by the same, such current depending on the functioning conditions of the fan F , its value is unique for each fan F model.

[0032] During the calibration or "characterization" procedure of the fan F , characterization curves are obtained of the fan by varying the supply voltage (V) and detecting the corresponding current absorbed (AC) by the motor of the fan F (see Figure 2 where the absorbed current AC is illustrated as a function of the supply voltage V).

[0033] A first curve, the curve A , is obtained in normal functioning conditions, which means that the motor of the fan F is power supplied, the air intake and the exhaust ducts of the burner are cleared and there are no mechanical malfunctions, such that the combustive air flow rate is sufficient to obtain good combustion. In general, a linear progression curve (a straight line) is obtained. In Fig. 2, V_n indicates the nominal functional voltage.

[0034] A second curve is obtained, curve B , by blocking the rotation of the wheel of the fan F , such that the flow rate of combustive air is equal to zero, since the fan F does not function. In such case, given the same supply voltage V_n of the motor of the fan F , the corresponding current absorbed AC by the motor is greater than that of the preceding case. A linear curve progression is obtained.

[0035] A third curve, the curve C , is obtained by disconnecting the wheel of the fan F from the shaft of its motor. Also in this case, the combustive air flow rate is equal to zero and the current AC absorbed by the motor of the fan F is less than that absorbed in normal function-

ing conditions (curve A). The progression of the curve C is also linear.

[0036] It will be noted that other working conditions can be taken into account in order to characterize the fan F. Thus, for example, a curve G (not shown in the drawings) can be obtained when the fan F is on, and the duct DT3 is completely or partially clogged.

[0037] The characterization procedure of the fan F then provides for a second step during which, with the burner on, among the possible flow rates of combustible gas supplied to the burner BR, the minimum supply voltage is identified that ensures a flow rate of combustible air sufficient to guarantee correct combustion.

[0038] Once the burner is turned on, and at the termination of the characterization procedure of the fan, the device 1 according to the present invention acquires, as specified above, by means of suitable circuit means such as the units 14 and 15, the value of the supply voltage V and the current absorbed AC by the motor of the fan F.

[0039] Once such values are acquired, the device 1 carries out two controls:

- it verifies that, for a given flow rate of combustible gas supplied to the burner, the supply voltage to the motor of the fan is greater than the minimum threshold value evaluated during the second step of the characterization procedure (values which are compared by the comparator circuit 10); and
- it verifies that the current absorbed by the motor of the fan does not diverge from the nominal functioning value by an interval greater than a predetermined quantity (curves of the diagram of Fig. 2).

[0040] If, after one of such controls, it results that the supply voltage V is less than the threshold value or that the current absorbed AC diverges too much from the value corresponding to the nominal value, the device 1 (or better yet its signal acquisition and processing unit 6) produces an output signal which either activates a signaling device (typically alarm), also remote, and/or interrupts the functioning, i.e. turns off the burner BR.

[0041] In Fig. 3, a block diagram is reported that illustrates the operating sequence of the control of the voltage V and the current AC applied to the motor of the fan F.

[0042] Initially, with burner BR turned off (block 301), the lighting of the burner is requested (block 302), giving a start control of the motor of the fan F (block 303). The measurement unit 14 at this point measures the supply voltage V of the motor of the fan F, and this is compared in the comparator circuit 10 with a minimum threshold value (block 305). If the supply voltage V measured results less than a minimum threshold value, i.e. an anomaly is verified (block 306), the signal acquisition and processing unit 6 produces an output error signal, which in the embodiment illustrated with reference to an atmospheric boiler blocks the lighting procedure of the burner BR. If the measured voltage is greater than a pre-established threshold value, then the current absorbed AC by

the motor of the fan F is detected (block 307) and the detected value is compared in the comparator circuit 11 in order to establish if it falls within the pre-established working range (block 308), i.e. if it diverges from the nominal functioning value. If the absorbed current AC diverges from the nominal functioning value by an interval greater than the working range, the signal acquisition and processing unit 6 produces an output error signal which prevents the lighting of the burner BR (block 306); otherwise, the lighting of the burner BR (block 309) is commanded.

[0043] Once the burner BR is lit and that, therefore, the flame is present, the device 1 can ensure the control of the burner and more particularly that the flow rate of combustible air is sufficient for guaranteeing that the percentage of unburned gases (like CO) is less than a threshold value. It can accomplish this in different ways, i.e. by monitoring:

- 1) the supply voltage V of the motor of the fan and the current absorbed AC by the motor of the fan F;
- 2) the flame ionization current FI; or
- 3) the supply voltage V of the motor of the fan, the current absorbed AC by the motor of the fan F and the flame ionization current FI.

[0044] The method for monitoring or controlling the supply voltage V and the current absorbed AC by the motor of the fan is similar to that described above with reference to the characterization procedure of the fan (see blocks 304 and 307, in particular).

[0045] It therefore provides for: predetermining a minimum value and a maximum value for the current absorbed by the motor of the supply means F; establishing, for a plurality of flow rate values of combustible gas supplied to the burner BR, the minimum supply voltage of the motor of the supply means F for ensuring a combustible air flow rate suitable for ensuring correct combustion; supplying combustible gas to the burner at a predetermined flow rate; detecting the supply voltage V of the supply means F and the absorbed current AC of the motor of the supply means F; verifying that, for the flow rate of supplied combustible gas, the supply voltage V is greater than a predetermined threshold value and that the value of the absorbed current AC does not diverge from a predetermined threshold value, and if at least one of the voltage V and current AC values does not respect the respective thresholds, generating an output control signal.

[0046] More particularly, if the supply voltage V measured is less than a minimum threshold, or if the supply voltage V measured is greater than the threshold value but the absorbed current AC diverges from the nominal functioning value by an interval greater than the working interval or range, then the signal acquisition and processing unit 6 produces an output error signal that commands the closing of the electric valve.

[0047] In accordance with the present invention, the

value of the flame ionization current is evaluated or monitored, in particular the detected value is used for controlling if there is a sufficient combustible air flow rate for ensuring good combustion (the closest possible to that stoichiometric).

[0048] As is known, there exists a very precise correlation between the temperature of the flame and the quality of the combustion and, in particular, between the temperature and the excess air index λ , which gives a precise indication with regard to the combustible air present. In addition, the temperature of the flame is correlated to the flame ionization current FI, according to Richardson's law. Therefore, there is a connection of proportionality between the flame ionization current FI and the excess combustible air index λ .

[0049] The flame ionization current FI is then measured by means of the transducer means 13, evaluating the excess air index λ .

[0050] The relation between the ionization current and the excess air λ is illustrated in Fig. 4, which shows a curve L with a maximum, where $\lambda=1$ in correspondence with stoichiometric combustion. During the normal functioning of an atmospheric boiler with closed chamber, the index λ is never less than 1.2 - 1.3 and the normal functioning area AI is indicated with a dotted area.

[0051] When the device 1 functions in work conditions corresponding to the area AI, if the combustible air flow rate decreases, the excess air index λ decreases and the flame ionization current FI correspondingly increases. When the value of the flame ionization current detected by the sensor means 12, 13 exceeds a specific threshold, this means that the air flow rate through the duct DT2 has become insufficient for a correct and safe combustion, so that the signal acquisition and processing unit 6 closes the electric valve EV and turns off the burner BR. Such threshold is determined during the characterization process or routine of the burner BR carried out during construction. Its value is corrected during periodic calibration processes in order to adapt it to the changing operating conditions of the device 1.

[0052] In Figure 5, the qualitative progression is illustrated of the curve obtained by correlating the flame ionization current FI and excess air index λ data, obtainable as indicated above for a specific burner model and for a specific boiler structure.

[0053] Then, the characterization procedure is carried out of the burner in order to determine the threshold curve corresponding to every possible combustible gas, curve which identifies the correct functioning of the burner BR.

[0054] During such procedure, three curves D, E and F are determined, which are a function of the combustible gas flow rate and the flame ionization current FI.

[0055] The curve D represents the expected value of the ionization current in normal functioning conditions, i.e. the link between the flame ionization current FI and the excess air index λ for the particular burner-boiler model. In order to obtain such curve, an optimal excess air index value is set, then for each combustible gas flow

rate the corresponding flame ionization current FI is measured. In such a manner, corresponding pairs of combustible gas flow rate values and ionization current values FI are obtained, reported in Figure 5.

[0056] The curve E instead represents the threshold value for each modulation level of the combustible gas flow rate. In order to obtain the curve E, one can, for example, determine a combustible gas flow rate value, decrease the combustible air flow rate and simultaneously detect, by means of the analyzer FA, the percentage of polluting substances such as carbon monoxide (CO) in the burner exhaust gases. When the percentage of polluting substances (e.g. carbon monoxide) reaches a threshold value, the corresponding flame ionization current value FI is measured and the point corresponding to the threshold ionization current and combustible gas flow rate is reported in the graph of Figure 5.

[0057] The threshold values of the carbon monoxide must be such to ensure that the quantity of carbon monoxide (CO) in the exhaust fumes remains less than 0.1% in any functioning condition, as established by current laws on the matter.

[0058] The curve F instead represents the minimum flame ionization current capable of allowing the detection of the flame presence.

[0059] The curves that are identified during the characterization procedure of the burner are related to optimal functioning conditions. Nevertheless, with the passage of time, phenomena can be verified (such as the aging of the electrode, the deposition of soot, the presence of impurities in the air or the formation of condensate) which can bring the aforesaid curves to "drift" with respect to the nominal values, i.e. that given the same combustible gas flow rate, lower flame ionization current values are obtained.

[0060] In order to modify the reference curves, so as to adapt them to the actual functioning conditions of the burner BR which account for the abovementioned phenomena, a periodic calibration procedure of the device 1 is provided for.

[0061] Such calibration procedure (see Fig. 6) provides for - after a suitable start calibration command (block 600) and after the lighting of the burner (block 601) - having a minimum combustible gas flow rate (block 602) and maintaining such fuel supply condition for a time sufficient for obtaining the stabilization of the device 1 (block 603), after which it proceeds to detect (block 606) the corresponding value of the flame ionization current FI. It compares the detected value for the purpose of checking if it falls within a pre-established interval or range (block 605). If the flame ionization current value FI diverges by a value greater than a threshold interval from the nominal values obtained during the characterization step, the management and adjustment unit 6 produces an output control signal (block 606) and the end of the calibration is commanded with the stopping of the burner BR (block 607).

[0062] Otherwise, the device 1 is supplied with a max-

imum combustible gas flow rate (block 608), such supply condition is maintained for a time sufficient for obtaining the stabilization of the device 1 (block 609) and then the corresponding value of the flame ionization current FI is detected (block 610). If the value falls within a predefined range, i.e. if the value detected with maximum gas flow rate diverges by a value smaller than a threshold interval from the nominal values obtained in characterization step (block 611), the two ionization current values thus acquired are used for suitably calibrating the reference curves (block 612); otherwise the management and adjustment unit 6 produces an alarm signal (block 606), and in both cases the calibration procedure terminates (block 607).

[0063] The calibration procedure of the system described above can be programmed so that it typically takes place:

- at the start of the first start request of the burner BR, after having connected the device 1 to the electrical power supply network;
- 24 hours the preceding calibration procedure;
- after a specific number of lightings of the burner BR; or
- each time that the measured flame ionization current FI diverges from that expected by more than a specific threshold.

[0064] During the functioning of the burner BR, the flame ionization current FI is continuously detected and acquired (see Fig. 7). After the lighting of the burner BR, the flame is certainly present (block 700), and its value is compared (block 701) with a threshold value connected with the supplied combustible gas flow rate (block 702).

[0065] If the detected ionization current value exceeds the threshold value, the management and adjustment unit 6 of the device produces an alarm or anomaly signal (block 703) which in the illustrated embodiment turns off the burner BR, or alternatively reduces the opening of the electric valve EV so as to supply a reduced flow rate of combustible gas. In such second case, the device preferably emits a functioning anomaly signal.

[0066] Preferably, it is continuously verified that there is monotonicity in the flame signal-gas flow rate ratio, i.e. that with the increase of the excess air index λ , the flame ionization current FI decreases. Such control serves to ensure that the device 1 operates within the correct work zone of Fig. 6, and therefore not in the zone related to values of λ less than 1.

[0067] More particularly, if the flame ionization current signal FI is less than the threshold value, it is evaluated if the modulation level or better yet the combustible gas flow rate is decreased (block 706) and, if it has, it is verified if the ionization current signal FI has also decreased (block 705). If both values are diminished, the described cycle is repeated starting from block 701, otherwise the management and adjustment unit 6 produces an error control signal (block 703), since with the decrease of the

gas flow rate, an increase of the flame ionization current value FI would have occurred and the burner BR would be functioning in an incorrect manner (see Figures 5 and 7).

[0068] If, instead, the combustible gas flow rate is not decreased, according to the method according to the present invention, it is evaluated if the flow rate is increased (block 706). If it is not, the cycle is repeated starting from the acquisition of the flame ionization signal FI (block 701), otherwise it is evaluated if also the flame ionization current signal FI is increased (block 707). If both the flow rate values of the combustible gas and the flame ionization current FI are increased, the burner BR functions regularly and the described routine is repeated starting from the block 701, otherwise the management and adjustment block 6 produces an anomaly or block signal, since the burner BR is clearly functioning in an incorrect manner (Figures 5 and 7).

[0069] Preferably, the control of the burner can be ensured and more particularly it can be ensured that the combustive air flow rate is sufficient for guaranteeing that the percentage of polluting substances in the exhaust (such as CO) is less than a threshold value by means of a combination of the above-described methods, i.e. by monitoring the supply voltage V of the motor of the fan, the current absorbed AC by the motor of the fan F and the flame ionization current FI; such method allows making a more accurate control with respect to the above-described methods.

[0070] In accordance with a method variant, during normal functioning, when the fan is driven at maximum speed, a variation or modulation (diminution) is commanded of the fan speed, so as to reduce the combustive air flow rate, and the flame ionization value is controlled until it coincides with the value corresponding with an excess air value λ equal to or corresponding with 1; at such value, as said, there is a stoichiometric ratio between the combustible fluid and the combustive air, and, therefore, there is correct combustion. If the speed of the fan was not modulated, it would not be possible to reach such functioning condition only by operating (opening) the electric valve EV. By varying the combustible fluid flow rate via the opening/closing of the electric valve (EV), the functioning area of the burner, as said above, is the area AI of Fig. 4, whereas for conditioning a functioning in the zone to the left of such area, it is necessary to operate (decrease) the combustive air flow rate.

[0071] The use of the device 1 according to the present invention in an atmospheric boiler of type C with forced suction allows avoiding the use of an air pressure switch for monitoring the combustive air. No air pressure switch is therefore required - and likewise no mechanical fixing components of the same to the boiler, no electrical connection, no pneumatic connection with the fan nor a Venturi tube for the fan are required. Such tube, as is known, presents serious condensate formation problems in the Venturi apparatus, which affect its functioning. The device 1 therefore also allows reducing the number of com-

ponents of the boiler with respect to the conventional solutions.

[0072] A device 1 according to the present invention therefore has mainly electronic and not mechanical functioning, and correctly functions independent of the stack length or of the structure of the burner BR or boiler CA, so that no problems occur with regard to the generation of signals not in keeping with the actual operative situation, or "false signals", as is not infrequently verified in conventional systems provided with pressure switch.

[0073] Moreover, it will be noted that the detection of actual effective values of supply voltage V_{eff} and current I_{eff} absorbed by the motor of the fan F enables one to acknowledge any change in the functioning of device 1 more rapidly and more accurately than with the devices disclosed in US-2005/0284463, US-5 806 440 and EP-1 331 444.

[0074] An air pressure switch, then, operates upon the attainment of a predetermined air pressure threshold and in a manner entirely independent of the combustible gas flow rate. According to methods based on the monitoring of the flame ionization current, however, it is possible to vary the threshold values at which an alarm or error message is produced, such threshold values being dependent on the actual combustible gas flow rate. This allows and ensures a correct functioning both of the burner BR and of the boiler CA also in the presence of low thermal flow rates, with partial obstruction of exhaust ducts, a condition in which a conventional air pressure switch would command functioning interruption.

[0075] The device and the methods according to the present invention can be set in such a manner so as to respect the requirements dictated by current law on the matter and allow continuously checking the combustible air flow rate, both at the start, before the lighting of the burner BR, i.e. in the absence of flame, and after the lighting of the burner.

[0076] The device according to the present invention therefore allows obtaining feedback from the fixed speed fan F of an atmospheric boiler CA of type C, obtaining a precise indication on its functioning status and, thus, on the combustible air flow rate.

Claims

1. A method of controlling the quality of combustion in a burner (BR) associated to a combustion chamber (CC), combustible air supply means (F) driven by a motor with fixed speed, at least one combustible fluid supply duct (DT1) interceptable by a respective electric valve means (EV), and at least one exhaust duct (DT3) for the combustion gases, said method comprising the following steps:

- predetermining a minimum value and a maximum value for the current absorbed by the motor of said supply means (F);

- establishing, for a plurality of flow rate values of combustible fluid supplied to the burner (BR), the minimum threshold value of the supply voltage of the motor of the supply means (F) for ensuring a combustible air flow rate suitable for ensuring correct combustion;
- supplying combustible fluid to said burner at a predetermined flow rate;
- detecting the supply voltage (V) of the motor of said supply means (F) and the current absorbed (AC) by the motor of said supply means (F);
- checking that, for the supplied combustible fluid flow rate, the supply voltage (V) of the motor of said air supply means (F) is greater than said established minimum threshold value and that the value of the current absorbed (AC) by the motor of said air supply means (F) does not diverge from the nominal functioning value by an interval greater than a predetermined quantity; and
- generating an output control signal when at least one of the values of voltage (V) and current (AC) does not comply with the respective thresholds, said output control signal comprising a command for controlling the opening/closing of said electric valve means (EV).

2. A method according to claim 1, **characterized in that** said output control signal is a closure control for said electric valve means (EV).

3. A method of controlling the quality of combustion in a burner (BR) associated to a combustion chamber (CC), combustible air supply means (F) driven by a motor with fixed speed, at least one combustible fluid supply duct (DT1) interceptable by a respective electric valve means (EV), and at least one exhaust duct (DT3) of the combustion gases, said method comprising the following steps:

- supplying combustible fluid at a predetermined flow rate;
- checking that the actual flame ionization current value (FI) in said combustion chamber (CC), which value is correlated to the quality of the combustion, does not exceed a predetermined threshold value corresponding to said predetermined flow rate, said predetermined threshold value being evaluated for a flame ionization current (FI) and for each combustible fluid flow rate, during a characterization process or routine of the burner (BR), and
- generating an output control signal when the detected flame ionization current value (FI) is greater than said threshold value, said output control signal comprising a command for controlling the opening/closing of said electric valve

means (EV).

4. A method according to claim 1, **characterized in that**, after the step of supplying combustible fluid to said burner at a predetermined flow rate it also comprises the step of:
 - checking that the actual flame ionization current value (FI) in said combustion chamber (CC), which value is correlated to the quality of the combustion, does not exceed a predetermined threshold value corresponding to said predetermined flow rate, said predetermined threshold value being evaluated for a flame ionization current (FI) and for each combustible fluid flow rate, during a characterization process or routine of the burner (BR), and
 - generating an output control signal when the detected flame ionization current value (FI) is greater than said threshold value, said output control signal comprising a command for controlling the opening/closing of said electric valve means (EV).
5. A method according to claim 3 or 4, **characterized in that** said output control signal is a closure control for said electric valve means (EV).
6. A method according to claim 3 or 5, **characterized in that** said characterization process of the burner comprises a step of evaluating a curve (E) representative of the flame ionization current (FI) threshold value for each combustible fluid supply flow rate, which is obtained by means of the following operations:
 - determining a combustible fluid flow rate value;
 - decreasing the combustive air flow rate;
 - detecting the percentage of polluting substances in the exhaust gases of the burner (BR), until the percentage of said polluting substances reaches a threshold level; and
 - obtaining the flame ionization current (FI) threshold value.
7. A method according to claim 6, **characterized in that** said characterization process provides for the determination of a curve (D) representative of the expected value of the flame ionization current (FI) as a function of the combustible fluid flow rate.
8. A method according to claim 7, **characterized in that** said curve (D) is obtained by setting an optimal value of excess air index (λ) and, for a plurality of values of combustible fluid flow rate, detecting the corresponding flame ionization current value (FI).
9. A method according to claim 7 or 8, **characterized**

in that it comprises the following operative steps:

- continuously checking that there is monotonicity between the combustible fluid flow rate and the flame ionization current, i.e. that with the increase of the excess air index (λ) the flame ionization current (FI) decreases or vice versa and,
 - in the absence of monotonicity, turning off the burner (BR) or adjusting the opening/closing of said electric valve means.
10. A method according to any claim 8 or 9, **characterized in that** said excess air index (λ) is used as an indicator of the percentage of carbon monoxide (CO) present in the current of the combustion fumes of the burner (BR).
 11. A method according to any claim 1 to 10, when not depending upon claim 3, **characterized in that** it comprises a characterization procedure of said supply means (F), and **in that** during a first step of the characterization procedure of said supply means (F), three curves are obtained as a function of the supply voltage (V) and the current (AC) absorbed by the motor of said supply means (F), by supplying said supply means (F) with multiple predetermined voltages (V) and detecting the corresponding absorbed current (AC):
 - a first curve (A) being obtained in normal functioning conditions, in which the combustive air flow rate is sufficient for obtaining good combustion;
 - a second curve (B) being obtained by blocking the rotation of the wheel of said supply means (F), in order to calculate maximum values of absorbed current for each supply voltage, and
 - a third curve (C) being obtained by disconnecting the wheel of said supply means (F) from the shaft of its motor, in order to calculate minimum values of absorbed current for each supply voltage.
 12. A method according to claim 11, **characterized in that** it comprises a calibration procedure of the burner (BR), comprising:
 - supplying combustible fluid at a minimum flow rate to the burner;
 - maintaining such supply condition for a sufficient time for attaining the stabilization of the burner (BR);
 - detecting the flame ionization current value (FI);
 - checking if the detected value falls within a pre-established range or interval;
 - if the flame ionization current value (FI) is within the pre-established range, proceeding with a

- subsequent step; or commanding the end of the calibration and generating an errorsignal;
 - supplying a maximum combustible fluid flow rate;
 - maintaining such supply condition for a time sufficient for obtaining the stabilization of the burner (BR);
 - detecting the corresponding flame ionization current value (FI);
 - checking if said detected value falls within a pre-established range or interval; and
 - when the flame ionization current value (FI) is within the range, the two ionization current values are used for calibrating the reference curve; when it is outside such range, the end of the calibration is commanded and an error signal is produced.
13. A method according to any claim 1 to 12, when not depending upon claim 3, **characterized in that** said detected supply voltage (V) of said supply means (F) and said current absorbed (AC) by the motor of said supply means (F) are effective values.
14. A method according to claim 13, **characterized in that** said effective current value (1 ett) is corrected by two correction factors, one correlated to the temperature of the motor winding and one correlated to the frequency.
15. A method according to claim 14, **characterized in that** said correction factors are defined during the "characterization" procedure of said fan (F).
16. A method according to claim 14 or 15, **characterized in that** said correction factor correlated to the winding temperature comprises a plurality of correction factors one for each temperature of the motor winding.
17. A control device for implementing the method of controlling the quality of combustion in a burner (BR) in an atmospheric boiler (CA) according to any claim 1 to 16, the burner being associated to a combustion chamber (CC), combustible air supply means (F) driven by a motor with fixed speed, at least one combustible fluid supply duct (DT1) interceptable by a respective electric valve means (EV) for adjusting the combustible fluid flow rate, at least one exhaust duct (DT3) for the combustion gases, said device including a control circuit board (2) having
- sensor means (12, 13) designed to detect the actual ionization current value of the flame (FI) in said combustion chamber (CC) and to produce output electrical signals correlated thereto;
 - detection means (14, 15) set to detect actual values of supply voltage (V) and current (AC)
- absorbed by the motor of said supply means (F) and to generate respective output signals;
 - a microprocessor (3) designed to produce output control signals in response to input signals correlated to said output electrical signals transmitted by said sensor means (12, 13) and said detection means (14, 15); wherein said control circuit board (2) also comprises
 - second signal converter means (8) designed to acquire output control signals from said microprocessor (3) and convert them into respective output signals representative of threshold values of supply voltage (V) and of current (AC) absorbed by the motor of said supply means (F); and
 - second and third signal comparator means (10, 11), which are set to receive in input, on one side, said output electrical signals transmitted by said detection means (14, 15) and, on the other side, said output signals of said second signal converter means (8) thereby comparing them and generating output signals to be applied as input signals to said microprocessor (3); and wherein said output control signal from said microprocessor (3) comprises a command or controlling the opening/closing of said electric valve means (EV).
18. A device according to claim 17, **characterized in that** it further comprises:
- first signal converter means (7) designed to generate threshold signals correlated with respective flame ionization current values and to operate in response to said output control signals of said microprocessor (3); and
 - first comparator means (9), which are set to receive in input both threshold signals generated by said first signal converter (7) and said output electrical signals transmitted by said sensor means (12, 13), said output electrical signals transmitted by said sensor means (12, 13) being correlated to the quality of the combustion in said combustion chamber (CC), thereby comparing them and generating output signals to be applied as input signals to said microprocessor (3).
19. A device according to claim 17 or 18, **characterized in that** said output control signal from said microprocessor (3) is a closure control for said electric valve means (EV).
20. A device according to any claim 17 to 19, **characterized in that** it comprises a fumes analyzer (FA) located in said exhaust duct (DT3) for the combustion gases.
21. A device according to any claim 18 to 20, **characterized in that** it further comprises:

terized in that said microprocessor (3) comprises a unit (6) for acquiring and processing signals received in input from said first, second and third comparator means (9, 10, 11) and a management and adjustment unit (6) designed to command possible variations of the opening/closing level of said electric valve means (EV).

22. A device according to any claim 18 to 21, **characterized in that** said microprocessor (3) is set:

to verify that, for the combustible fluid flow rate corresponding with a specific opening of said electric valve means (EV), the supply voltage (V) of said supply means (F) is greater than a minimum threshold value and that the value of the current absorbed (AC) by the motor of said air supply means (F) does not diverge from the nominal functioning value by an interval greater than a predetermined quantity ;

to check that the actual flame ionization current value (FI) does not exceed a predetermined threshold value, and

if at least one of the values of voltage (V) of said supply means (F), of current (AC) of the motor of said supply means (F) and of flame ionization current (FI) does not respect the respective thresholds, to generate an output control signal.

23. A device according to any claim 17 to 22, **characterized in that** said supply means (F) are suction means.

24. A device according to any claim 17 to 23, **characterized in that** said burner (BR) is a component of a boiler.

Patentansprüche

1. Verfahren zur Überprüfung der Verbrennungsqualität in einem Brenner (BR), der einer Brennkammer (CC) zugeordnet ist, wobei Verbrennungsluftzufuhrmittel von einem Motor mit fester Drehzahl betätigt werden, wobei mindestens ein Brennstoffzuführungsrohr (DT1) für ein brennbares Fluid vorgesehen ist, das von einem jeweiligen elektrischen Ventil (EV) abgefangen werden kann und von mindestens einem Abgasrohr (DT3) für die Verbrennungsgase abgefangen werden kann wobei das Verfahren folgende Schritte umfasst:

- Vorgabe von einem Minimalwert und einem Maximalwert für den vom Motor der genannten Zuführeinrichtung (F) aufgenommenen Strom;
- Bestimmung, für eine Mehrzahl von Werte einer Strömungsrate von Brennstofffluid, die dem Brenner (BR) zugeführt wird, des Mindest-

schwellwerts der Versorgungsspannung des Motors der Zuführeinrichtung (F), um eine Strömungsrate von Verbrennungsluft zu gewährleisten, die angepasst ist, um eine korrekte Verbrennung zu gewährleisten;

- Zuführung von einem brennbaren Fluid zu dem genannten Brenner mit einer vorbestimmten Strömungsrate;

- Erfassung der Versorgungsspannung (V) des Motors der genannten Versorgungseinrichtung (F) und des von dem Motor der genannten Versorgungseinrichtung (F) aufgenommenen Stromes (AC);

- Prüfung, dass für den Fluss des zugeführten Brennstofffluidstroms die Versorgungsspannung (V) des Motors der genannten Versorgungseinrichtung (F) höher ist als der festgelegte Mindestschwellwert und dass der Wert des vom Motor der Versorgungseinrichtung (F) aufgenommenen Stroms (AC) sich nicht von dem Nennbetriebswert gemäß einem Integral unterscheidet, das größer als eine vorbestimmte Menge ist; und

- Erzeugung von einem allgemeinen Ausgabebefehlssignal, wenn mindestens einer der Spannung (V)- und Stromwerte (AC) nicht den jeweiligen Schwellenwerten entspricht, wobei das genannte Ausgabebefehlssignal einen Befehl zum Steuern des Öffnens/Schließens des elektrischen Ventils umfasst.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das genannte Ausgabebefehlssignal ein Schließbefehl für das elektrische Ventil (EV) ist.

3. Verfahren zur Überprüfung der Verbrennungsqualität in einem Brenner (BR), der einer Verbrennungskammer (CC) zugeordnet ist, mit einer Verbrennungsluftzuführeinrichtung (F), die von einem Motor mit fester Drehzahl angetrieben wird, wobei mindestens ein Brennstoffzuführrohr (DT1) eines brennbaren Fluides von einem jeweiligen elektrischen Ventil (EV) aufgefangen werden kann und von mindestens einem Verbrennungsgasauslassrohr (DT3), aufgefangen werden kann, wobei das Verfahren folgende Schritte umfasst:

- Zuführung eines fluiden Brennstoffs mit einer vorbestimmten Strömungsrate;

- Prüfung, dass der aktuelle Wert eines Flammenionisationsstroms (FI) in der genannten Verbrennungskammer (CC), der sich auf die Qualität der Verbrennung bezieht, einen vorbestimmten Schwellenwert nicht überschreitet, der der genannten vorbestimmten Strömungsrate entspricht, wobei der genannte vorbestimmte Wert für einen Flammenionisations-

- strom (FI) und für jede Strömungsrate von brennbarem Fluid, während eines Vorgangs oder Zyklus des Brenners, ausgewertet wird, und
- Erzeugung eines Ausgabebefehlssignals, wenn der erfasste Flammenionisationsstromwert (FI) höher als der genannte Schwellenwert ist, wobei das genannte Ausgabebefehlssignal einen Befehl zum Steuern des Öffnens/Schließens des elektrischen Ventils (EV) umfasst.
4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** es nach dem Schritt der Zuführung eines brennbaren Fluides zum genannten Brenner mit einer vorbestimmten Flussrate, auch folgende Schritte umfasst:
- Prüfung, dass der aktuelle Flammenionisationsstromwert (FI) in der genannten Verbrennungskammer (CC), dessen Wert sich auf die Qualität der Verbrennung bezieht, einen vorbestimmten Schwellenwert nicht überschreitet, der der genannten vorbestimmten Strömungsrate entspricht, wobei der genannte vorbestimmte Schwellenwert für einen Flammenionisationsstrom (FI) und für jede Flussrate eines brennbaren Fluides während eines Brennerprozesses oder eines Charakterisierungszyklus des Brenners (BR) ausgewertet wird, und
 - Erzeugung von einem Ausgabebefehlssignal, wenn der erfasste Flammenionisationsstromwert (FI) höher als der genannte Schwellenwert ist, wobei das genannte Ausgabebefehlssignal einen Befehl zum Steuern des Öffnens/Schließens des genannten elektrischen Ventils (EV) umfasst.
5. Verfahren nach Anspruch 3 oder 4, **dadurch gekennzeichnet, dass** das genannte Ausgabebefehlssignal ein Schließbefehl für das genannte elektrische Ventil (EV) ist.
6. Verfahren nach Anspruch 3 oder 5, **dadurch gekennzeichnet, dass** der genannte Brennercharakterisierungsprozess einen Auswertungsschritt einer Kurve (E) umfasst, der den Schwellenwert des Flammenionisationsstromes (FI) für jede Flussrate des Brennstofffluides darstellt, die durch folgende Schritte erhalten wird:
- Bestimmung von einer Strömungsrate der Kraftstofffluidstroms;
 - Verringerung der Verbrennungsluftströmungsrate;
 - Messung vom Prozentsatz an Schadstoffen in den Abgasen des Brenners (BR), bis der Prozentsatz dieser genannten Schadstoffe einen Schwellenwert erreicht; und
- Erhalten des Schwellenwerts des Flammenionisationsstromes (FI).
7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, dass** der genannte Charakterisierungsprozess die Bestimmung einer Kurve (D) durchführt, die für den erwarteten Wert des Flammenionisationsstromes (FI) als Funktion der Strömungsrate des brennbaren Fluides repräsentativ ist.
8. Verfahren nach Anspruch 7, **dadurch gekennzeichnet, dass** die genannte Kurve (D) durch Einstellen eines optimalen Wertes eines Luftüberschussindex (A) und durch Erfassen des entsprechenden Flammenionisationsstromwerts (FI) für eine Vielzahl von Flussraten von brennbarem Fluid, erhalten wird.
9. Verfahren nach Anspruch 7 oder 8, **dadurch gekennzeichnet, dass** es folgende Schritte umfasst:
- ständige Überprüfung des Vorhandenseins eines monotonen Zustands zwischen der Strömungsrate des brennbaren Fluides und dem Flammenionisationsstrom, und zwar, dass der Flammenionisationsstrom (FI) mit dem Anstieg des Luftüberschussindex (A) abnimmt oder umgekehrt, und
 - wenn kein monotoner Zustand vorliegt, Einstellung der Ausschaltung des Brenners (BR) oder Öffnung/Schließung des elektrischen Ventils.
10. Verfahren nach einem der Ansprüche 8 oder 9, **dadurch gekennzeichnet, dass** der genannte Luftüberschussindex (A) als ein Indikator für den im Verbrennungsstrom des Brenners (BR) vorhandenen Prozentsatz an Kohlenmonoxid (CO) verwendet wird.
11. Verfahren nach einem der Ansprüche 1 bis 10, sofern nicht von Anspruch 3 abhängig, **dadurch gekennzeichnet, dass** es eine Prozedur zum Charakterisieren der genannten Zuführeinrichtung (F) umfasst, und dass während eines ersten Schritts der Charakterisierungsprozedur der genannten Zuführeinrichtung (F) drei Kurven als eine Funktion der Versorgungsspannung (V) und des durch den Motor der genannten Zuführeinrichtung absorbierten Stroms (AC) erhalten werden, wobei die genannte Zuführeinrichtung mit einer Vielzahl von vorbestimmten Spannungen (V) versorgt wird und der entsprechende absorbierte Strom (AC) erfasst wird;
- unter normalen Betriebsbedingungen wird eine erste Kurve (A) erhalten, in der die Strömungsrate der Verbrennungsluft ausreicht, um eine gute Verbrennung zu erreichen;
 - eine zweite Kurve (B) wird erhalten, indem die

- Drehung des Rades der genannten Zuführeinrichtung (F) blockiert wird, um Maximalwerte des für jede Versorgungsspannung absorbierten Stroms zu berechnen, und
- eine dritte Kurve (C) wird erhalten, indem das Rad der genannten Zuführeinrichtung von der Welle seines Motors getrennt wird, um minimale Werte des aufgenommenen Stroms für jede Versorgungsspannung zu berechnen.
12. Verfahren nach Anspruch 11, **dadurch gekennzeichnet, dass** es eine Kalibrierungsprozedur des Brenners (BR) umfasst, umfassend:
- Zufuhr eines brennbaren Fluides mit einer minimalen Strömungsrate zum Brenner;
 - Aufrechterhaltung eines solchen Versorgungszustands für eine ausreichende Zeit, um eine Stabilisierung des Brenners (BR) zu erreichen;
 - Erfassung des Flammenionisationsstromwertes (FI);
 - Prüfung, ob der gemessene Wert innerhalb eines zuvor festgelegten Bereichs oder Intervall liegt;
 - liegt der Flammenionisationsstromwert innerhalb des vorab festgelegten Intervalls, so wird entweder ein nachfolgender Schritt durchgeführt, oder das Ende der Kalibrierung wird gesteuert und ein Fehlersignal wird erzeugt;
 - Zuführung einer maximalen Flussrate des brennbaren Fluides;
 - Aufrechterhaltung eines solchen Versorgungszustands für eine ausreichende Zeit, um eine Stabilisierung des Brenners (BR) zu erreichen;
 - Erfassung des entsprechenden Flammenionisationsstromwertes (FI);
 - Prüfung, ob der genannte gemessene Wert innerhalb eines zuvor festgelegten Bereichs oder Intervall liegt; und
 - liegt der Flammenionisationsstromwert (FI) in diesen Bereich, so werden die zwei Ionisierungsstromwerte zum Kalibrieren der Referenzkurve verwendet. Befindet sich dieser außerhalb dieses Bereichs, wird das Ende der Kalibrierung gesteuert und wird ein Fehlersignal ausgegeben.
13. Verfahren nach einem der Ansprüche 1 bis 12, sofern nicht von Anspruch 3 abhängig, **dadurch gekennzeichnet, dass** die erfasste Versorgungsspannung (V) der genannten Zuführungseinrichtung (F) und der vom Motor der genannten Zuführeinrichtung aufgenommene Strom (F), tatsächliche Werte sind.
14. Verfahren nach Anspruch 13, **dadurch gekennzeichnet, dass** der genannte Stromistwert (I_{eff}) mittels zweier Korrekturfaktoren korrigiert wird, von denen einer auf die Temperatur der Motorwicklung und
- einer auf die Frequenz bezogen ist.
15. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, dass** die genannten Korrekturfaktoren während der Prozedur der "Charakterisierung" des genannten Lüfters (F) definiert werden.
16. Verfahren nach Anspruch 14 oder 15, **dadurch gekennzeichnet, dass** der genannte mit der Wicklungstemperatur korrelierte Korrekturfaktor mehrere Korrekturfaktoren umfasst, einen für jede Temperatur der Motorwicklung.
17. Steuervorrichtung zur Durchführung des Verfahrens zur Kontrolle der Verbrennungsqualität in einem Brenner (BR) in einem unter atmosphärischen Bedingungen arbeitenden Kessel (CA) nach einem der Ansprüche 1 bis 16, wobei der Brenner einer Brennkammer (CC) mit einer Zuführeinrichtung von Verbrennungsluft zugeordnet ist, die von einem Motor mit fester Geschwindigkeit angetrieben wird, wobei mindestens eine Kraftstoffzufuhrleitung (DT1) eines brennbaren Fluides mittels eines jeweiligen elektrischen Ventils (EV) zum Regulieren des Flusses des Brennstofffluidstroms mit mindestens einem Auslassrohr (DT3) für die Verbrennungsgase aufgefangen wird, wobei die genannte Vorrichtung eine Basis einer Steuerschaltung (2) umfasst mit
- Sensoren (12, 13), die dazu ausgelegt sind, den aktuellen Wert eines Flammen-Ionisationsstroms (FI) in der genannten Verbrennungskammer (CC) zu erfassen und damit verbundene elektrische Ausgangssignale zu erzeugen;
 - eine Erfassungseinrichtung (14, 15), die dazu eingerichtet ist, tatsächliche Werte einer Versorgungsspannung (V) und eines durch den Motor der Versorgungseinrichtung aufgenommenen Stroms (AC) zu erfassen und jeweilige Ausgangssignale zu erzeugen;
 - einen Mikroprozessor (3), der dazu ausgelegt ist, Ausgangssteuersignale als Reaktion auf Eingangssignale zu erzeugen, die sich auf die elektrischen Ausgangssignale beziehen, die von den genannten Sensoren (12, 13) und den genannten Erfassungseinrichtungen (14, 15) übertragen werden;
- in welchem
- die genannte Steuerschaltungsbasis ferner umfasst
- einen zweiten Signalwandler (8), der dazu ausgebildet ist, Ausgangsbefehlssignale von dem genannten Mikroprozessor (3) zu empfangen und in entsprechende Ausgangssignale umzuwandeln, die Schwellwerte einer Versorgungsspannung (V) und eines von dem Motor der genannten Zuführeinrichtung aufgenommenen Stroms (AC) darstellen; und

- einen zweiten und einen dritten Signalwandler (10, 11), die derart eingestellt sind, dass sie auf einer Seite die von der genannten Erfassungseinrichtung (14, 15) übertragenen elektrischen Ausgangssignale empfangen, und auf der anderen Seite die Ausgangssignale des genannten zweiten Signalwandlers (8) derart empfangen, dass sie auf diese Weise solche Signale vergleichen und Ausgangssignale erzeugen, die als Eingangssignale an den genannten Mikroprozessor (3) angelegt werden sollen; und in welchem das genannt Ausgangssteuersignal von dem genannten Mikroprozessor (3) einen Befehl oder eine Steuerung des Öffnens/Schließens des elektrischen Ventils (EV) umfasst.

18. Vorrichtung nach Anspruch 17, dadurch gekennzeichnet, dass sie ferner umfasst:

- einen ersten Signalwandler (7), der dazu ausgelegt ist, Schwellensignale zu erzeugen, die mit den jeweiligen Flammenorganisationsstromwerten korrelieren und in Reaktion auf die genannten Ausgangssignale des genannten Mikroprozessors (3) arbeiten können; und
- einen ersten Wandler (9), der derart eingestellt ist, dass er sowohl die durch den ersten Signalwandler (7) erzeugten Schwellensignale als auch die von dem genannten Sensor (12, 13) übertragenen elektrischen Ausgangssignale empfängt, wobei die genannten vom genannten Sensor (12, 13) übertragenen elektrischen Ausgangssignale auf die Qualität der Verbrennung in der genannten Verbrennungskammer (CC) bezogen sind, wodurch diese verglichen werden und Ausgangssignale erzeugen, die als Eingangssignale an den genannten Mikroprozessor (3) angelegt werden.

19. Vorrichtung nach Anspruch 17 oder 18, dadurch gekennzeichnet, dass das genannte Ausgabebefehlssignal von dem Mikroprozessor (3) ein Schließbefehl für das genannte elektrische Ventil (EV) ist.

20. Vorrichtung nach einem der Ansprüche 17 bis 19, dadurch gekennzeichnet, dass sie einen Rauchgasanalysator (FA) umfasst, der in dem genannten Abgasrohr (DT3) für die Verbrennungsgase angeordnet ist.

21. Vorrichtung nach einem der Ansprüche 18 bis 20, dadurch gekennzeichnet, dass der genannte Mikroprozessor (3) eine Einheit (6) zum Empfangen und Verarbeiten von am Eingang des ersten, zweiten und dritten Wandlers (9, 10, 11) empfangenen Signalen aufweist und eine Verwaltungs- und Regulie-

rungseinheit (6) dazu bestimmt ist, mögliche Variationen des zu steuernden Öffnung/Schließungsgrad des genannten elektrischen Ventils (EV) zu steuern.

22. Vorrichtung nach einem der Ansprüche 18 bis 21, dadurch gekennzeichnet, dass der genannte Mikroprozessor (3) eingestellt ist:

um zu verifizieren, dass für die Strömung des Brennstofffluides, die einer bestimmten Öffnung des genannten elektrischen Ventils (EV) entspricht, die Versorgungsspannung der genannten Zuführeinrichtung höher als ein minimaler Schwellenwert ist und dass der Wert des Stroms (AC), der durch den Motor des genannten Zuführeinrichtung (F) aufgenommen wird, sich nicht von dem Nennbetriebswert gemäß einem Intervall unterscheidet, das größer als eine vorbestimmte Menge ist;
um zu überprüfen, dass der aktuelle Flammenionisationsstromwert (FI) einen vorbestimmten Schwellenwert nicht überschreitet, und wenn mindestens einer der Spannungswerte der genannten Zuführeinrichtung (F), des Stroms (AC) des Motors der genannten Zuführeinrichtung (F) und des Flammenionenstroms (FI), nicht den jeweiligen Schwellenwerten entspricht, um ein Ausgangsbefehlssignal zu erzeugen.

23. Vorrichtung nach einem der Ansprüche 17 bis 22, dadurch gekennzeichnet, dass die genannte Zuführeinrichtung eine Saugeinrichtung ist.

24. Vorrichtung nach einem der Ansprüche 17 bis 23, dadurch gekennzeichnet, dass der genannte Brenner (BR) Bestandteil eines Kessels ist.

Revendications

1. Procédé de contrôle de la qualité de la combustion dans un brûleur (BR) associé à une chambre de combustion (CC), des moyens d'alimentation en air de combustion (F) étant actionnées par un moteur à vitesse fixe, au moins un tuyau d'alimentation pour un fluide combustible (DT1) pouvant être intercepté par une vanne respective (EV) et au moins un tuyau d'échappement (DT3) pour les gaz de combustion, ledit procédé comprenant les opérations suivantes:

- prédéterminer une valeur minimale et une valeur maximale pour le courant absorbé par le moteur desdits moyens d'alimentation (F);
- établir, pour une pluralité de valeurs d'un débit de fluide combustible fourni au brûleur (BR), la valeur de seuil minimale de la tension d'alimentation du moteur des moyens d'alimentation (F)

afin de garantir un débit d'air de combustion apte à garantir une combustion correcte;

- alimenter un fluide combustible audit brûleur avec un débit prédéterminé;

- détecter la tension d'alimentation (V) du moteur desdits moyens d'alimentation (F) et le courant absorbé (AC) par le moteur desdits moyens d'alimentation (F);

- vérifier que, pour l'écoulement du débit de fluide combustible alimenté, la tension d'alimentation (V) du moteur desdits moyens d'alimentation (F) est supérieure à ladite valeur de seuil minimale établie et que la valeur du courant absorbé (AC) par le moteur desdits moyens d'alimentation d'air (F) ne diffère pas de la valeur de fonctionnement nominale selon un intervalle supérieur à une quantité prédéterminée; et

- générer un signal de commande de sortie quand au moins une des valeurs de tension (V) et de courant (AC) n'est pas conforme aux seuils respectifs, ledit signal de commande de sortie comprenant une commande pour commander l'ouverture/fermeture de ladite électrovanne (EV).

2. Procédé selon la revendication 1, **caractérisé en ce que** ledit signal de commande de sortie est une commande de fermeture pour ladite électrovanne (EV).

3. Procédé de contrôle de la qualité de la combustion dans un brûleur (BR) associé à une chambre de combustion (CC), avec des moyens d'alimentation en air de combustion (F) entraînés par un moteur à vitesse fixe, avec au moins un tuyau d'alimentation en combustible d'un fluide combustible (DT1) qui peut être intercepté respectivement par une électrovanne (EV), et avec au moins un tuyau d'évacuation (DT3) des gaz de combustion, ledit procédé comprenant les opérations suivantes:

- alimenter un fluide combustible avec un débit prédéterminé;

- vérifier que la valeur actuelle d'un courant d'ionisation de flamme (FI) dans ladite chambre de combustion (CC), laquelle valeur est liée à la qualité de la combustion, ne dépasse pas une valeur de seuil prédéterminée correspondant audit débit prédéterminé, ladite valeur de seuil prédéterminée étant prévue pour un courant d'ionisation de flamme (FI) et pour chaque débit de fluide combustible, pendant un processus ou un cycle de caractérisation du brûleur (BR), et

- générer un signal de commande de sortie lorsque la valeur du courant d'ionisation de flamme (FI) détectée est supérieure à ladite valeur de seuil, ledit signal de commande de sortie comprenant une commande pour commander l'ouverture/fermeture de ladite électrovanne

(EV).

4. Procédé selon la revendication 1, **caractérisé en ce que**, après l'opération d'alimentation en fluide combustible audit brûleur avec un débit prédéterminé, il comprend également les opérations suivantes:

- vérifier que la valeur actuelle du courant d'ionisation de flamme (FI) dans ladite chambre de combustion (CC), laquelle valeur est liée à la qualité de la combustion, ne dépasse pas une valeur de seuil prédéterminée correspondant audit débit prédéterminé, ladite valeur de seuil prédéterminée étant évaluée pour un courant d'ionisation de flamme (FI) et pour chaque débit de fluide combustible, au cours d'un processus ou d'un cycle de caractérisation du brûleur (BR), et

- générer un signal de commande de sortie lorsque la valeur du courant d'ionisation de flamme (FI) détectée est supérieure à ladite valeur de seuil, ledit signal de commande de sortie comprenant une commande pour commander l'ouverture/fermeture de ladite électrovanne (EV).

5. Procédé selon la revendication 3 ou 4, **caractérisé en ce que** ledit signal de commande de sortie est une commande de fermeture de ladite électrovanne (EV).

6. Procédé selon la revendication 3 ou 5, **caractérisé en ce que** ledit processus de caractérisation du brûleur comprend une opération d'évaluation d'une courbe (E) représentative de la valeur de seuil du courant d'ionisation de flamme (FI) pour chaque débit de fluide combustible, qui est obtenu au moyen des opérations suivantes:

- déterminer un débit de fluide combustible;

- diminuer le débit d'air de combustion;

- mesurer le pourcentage de substances polluantes dans les gaz d'échappement du brûleur (BR) jusqu'à ce que le pourcentage de ces substances polluantes atteigne une valeur de seuil; et

- obtenir la valeur de seuil du courant d'ionisation de flamme (FI).

7. Procédé selon la revendication 6, **caractérisé en ce que** ledit processus de caractérisation réalise la détermination d'une courbe (D) représentative de la valeur attendue du courant d'ionisation de flamme (FI), en fonction du débit de fluide combustible.

8. Procédé selon la revendication 7, **caractérisé en ce que** ladite courbe (D) est obtenue en fixant une valeur optimale d'un indice d'air en excès (λ) et en dé-

tectant, pour une pluralité de valeurs du débit de fluide combustible, la valeur correspondante du courant de ionisation de flamme (FI).

9. Procédé selon la revendication 7 ou 8, **caractérisé en ce qu'il** comprend les opérations suivantes:

- vérifier en permanence l'existence d'une condition monotone entre le débit de fluide combustible et le courant d'ionisation de flamme, c'est-à-dire si le courant d'ionisation de flamme (FI) diminue avec l'augmentation de l'indice d'air en excès (λ), ou inversement, et
- en l'absence d'une condition monotone, éteindre le brûleur (BR) ou régler l'ouverture/fermeture de ladite électrovanne.

10. Procédé selon l'une des revendications 8 ou 9, **caractérisé en ce que** ledit indice d'air en excès (λ) est utilisé comme un indicateur du pourcentage de monoxyde de carbone (CO) présent dans le courant des fumes de combustion du brûleur (BR).

11. Procédé selon l'une des revendications 1 à 10, s'il ne dépend pas de la revendication 3, **caractérisé en ce qu'il** comprend une procédure de caractérisation desdits moyens d'alimentation (F), et que lors d'une première opération de la procédure de caractérisation desdits moyens d'alimentation (F), trois courbes sont obtenues en fonction de la tension d'alimentation (V) et du courant (AC) absorbés par le moteur desdits moyens d'alimentation (F), alimentant lesdits moyens d'alimentation (F) avec une pluralité de tensions prédéterminées (V) et détectant le courant absorbé correspondant (AC);

- une première courbe (A) étant obtenue dans des conditions normales de fonctionnement, dans lesquelles le débit d'air de combustion est suffisant pour obtenir une bonne combustion;
- une deuxième courbe (B) étant obtenue en bloquant la rotation de la roue desdits moyens d'alimentation (F), afin de calculer les valeurs maximales du courant absorbé pour chaque tension d'alimentation, et
- une troisième courbe (C) étant obtenue en déconnectant la roue desdits moyens d'alimentation (F) de l'arbre de son moteur, afin de calculer des valeurs minimales de courant absorbé pour chaque tension d'alimentation.

12. Procédé selon la revendication 11, **caractérisé en ce qu'il** comprend une procédure d'étalonnage du brûleur (BR), comprenant:

- alimentation d'un fluide combustible avec un débit minimal au brûleur;
- maintien d'une telle condition d'alimentation

pendant un temps suffisant pour obtenir la stabilisation du brûleur (BR);

- détection de la valeur du courant d'ionisation de flamme (FI);
- vérification, si la valeur détectée se situe dans une plage ou intervalle préétablis,
- si la valeur du courant d'ionisation de flamme (FI) se situe dans l'intervalle préétabli, procéder à une opération ultérieure; ou commander la fin de l'étalonnage et générer un signal d'erreur;
- alimentation d'un débit maximum de fluide combustible;
- maintien d'une telle condition d'alimentation pendant un temps suffisant pour obtenir la stabilisation du brûleur (BR);
- détection de la valeur du courant d'ionisation de flamme correspondant (FI);
- contrôle, si ladite valeur mesurée se situe dans une plage ou intervalle préétablis; et
- quand la valeur du courant d'ionisation de flamme (FI) se situe dans cette plage, les deux valeurs du courant d'ionisation sont utilisées pour étalonner la courbe de référence; lorsqu'elle se situe en dehors de cette plage, la fin de l'étalonnage est commandée et un signal d'erreur est généré.

13. Procédé selon l'une des revendications 1 à 12, s'il ne dépend pas de la revendication 3, **caractérisé en ce que** ladite tension d'alimentation (V) détectée desdits moyens d'alimentation (F) et ledit courant absorbé (AC) par le moteur desdits moyens d'alimentation (F) sont des valeurs réelles.

14. Procédé selon la revendication 13, **caractérisé en ce que** ladite valeur de courant réelle (I_{eff}) est corrigée au moyen de deux facteurs de correction, l'un lié à la température de l'enroulement du moteur et l'autre à la fréquence.

15. Procédé selon la revendication 14, **caractérisé en ce que** lesdits facteurs de correction sont définis lors de la procédure de "caractérisation" dudit ventilateur (F).

16. Procédé selon la revendication 14 ou 15, **caractérisé en ce que** ledit facteur de correction corrélé à la température de l'enroulement comprend une pluralité de facteurs de correction, un pour chaque température de l'enroulement du moteur.

17. Dispositif de contrôle pour la mise en oeuvre du procédé de contrôle de la qualité de combustion dans un brûleur (BR) dans une chaudière (CA) fonctionnant dans des conditions atmosphériques selon l'une des revendications 1 à 16, le brûleur étant associé à une chambre de combustion (CC), avec des moyens d'alimentation d'air de combustion (F) en-

traînés par un moteur à vitesse fixe, avec au moins une conduite d'alimentation en carburant (DT1) d'un fluide combustible pouvant être interceptée par une électrovanne respective (EV) pour la régulation du débit du fluide combustible, avec au moins un tuyau d'échappement (DT3) pour les gaz de combustion, ledit dispositif comprenant une base d'un circuit de commande (2) avec

- des capteurs (12, 13) conçus pour détecter la valeur actuelle d'un courant d'ionisation de flamme (FI) dans ladite chambre de combustion (CC) et pour produire des signaux de sortie électriques y relatifs;

- des moyens de détection (14, 15) réglés pour détecter les valeurs réelles d'une tension d'alimentation (V) et d'un courant (AC) absorbé par le moteur desdits moyens d'alimentation (F) et pour générer des signaux de sortie respectifs;
- un microprocesseur (3) conçu pour produire des signaux de commande de sortie en réponse à des signaux d'entrée associés auxdits signaux de sortie électriques transmis par lesdits capteurs (12, 13) et lesdits moyens de détection (14, 15); dans lequel ladite base de circuit de commande (2) comprend en outre

- un deuxième convertisseur de signal (8) conçu pour recevoir des signaux de commande de sortie provenant dudit microprocesseur (3) et pour les convertir en signaux de sortie respectifs représentatifs de valeurs de seuil d'une tension d'alimentation (V) et d'un courant (AC) absorbé par le moteur desdits moyens d'alimentation; et

- des deuxième et troisième comparateurs de signaux (10, 11), qui sont réglés pour recevoir d'un côté les signaux de sortie électriques transmis par lesdits moyens de détection (14, 15) et de l'autre côté, lesdits signaux de sortie dudit deuxième convertisseur de signaux (8), en les comparant de cette manière et en générant des signaux de sortie à appliquer en tant que signaux d'entrée audit microprocesseur (3);

et dans lequel

ledit signal de commande de sortie provenant dudit microprocesseur (3) comprend une commande ou un contrôle de l'ouverture/fermeture de ladite électrovanne (EV).

18. Dispositif selon la revendication 17, **caractérisé en ce qu'il** comprend en outre:

- un premier convertisseur de signal (7) conçu pour générer des signaux de seuil corrélés à

des valeurs de courant d'ionisation de flamme respectives et capable de fonctionner en réponse auxdits signaux de sortie dudit microprocesseur (3); et

- un premier comparateur (9), qui est réglé pour recevoir en entrée à la fois les signaux de seuil générés par ledit premier convertisseur de signal (7) et lesdits signaux de sortie électriques étant transmis par ledit capteur (12, 13), lesdits signaux de sortie électriques émis par ledit capteur (12, 13) étant liés à la qualité de combustion dans ladite chambre de combustion (CC), en les comparant ainsi et en générant des signaux de sortie à appliquer en tant que signaux d'entrée audit microprocesseur (3).

19. Dispositif selon la revendication 17 ou 18, **caractérisé en ce que** ledit signal de commande de sortie dudit microprocesseur (3) est une commande de fermeture pour ladite électrovanne (EV).

20. Dispositif selon l'une des revendications 17 à 19, **caractérisé en ce qu'il** comprend un analyseur de fumées (FA), disposé dans ledit tuyau d'échappement (DT3) pour les gaz de combustion.

21. Dispositif selon l'une des revendications 18 à 20, **caractérisé en ce que** ledit microprocesseur (3) comprend une unité (6) de réception et de traitement des signaux reçus en entrée desdits premiers, deuxième et troisième comparateurs (9, 10, 11) et une unité (6) de gestion et de régulation destinée à contrôler les éventuelles variations du niveau d'ouverture/fermeture de ladite électrovanne (EV).

22. Dispositif selon l'une des revendications 18 à 21, **caractérisé en ce que** ledit microprocesseur (3) est réglé:

pour vérifier que, pour le débit de fluide combustible correspondant à une ouverture spécifique de ladite électrovanne (EV), la tension d'alimentation (V) desdits moyens d'alimentation (F) est supérieure à une valeur de seuil minimale et que la valeur du courant absorbé (AC) par le moteur desdits moyens d'alimentation d'air (F) ne diffère pas de la valeur de fonctionnement nominale selon un intervalle supérieur à une quantité prédéterminée;

à fin de vérifier que la valeur actuelle du courant d'ionisation de flamme (F) ne dépasse pas une valeur de seuil prédéterminée, et si au moins une des valeurs de tension (V) desdits moyens d'alimentation (F) du courant (AC) du moteur desdits moyens d'alimentation (F) et du courant d'ionisation de flamme (FI) n'est pas conforme aux seuils respectifs, de manière à générer un signal de commande de sortie.

23. Dispositif selon l'une des revendications 17 à 22, **caractérisé en ce que** lesdits moyens d'alimentation (F) sont des moyens d'aspiration.

24. Dispositif selon l'une des revendications 17 à 23, **caractérisé en ce que** le dit brûleur (BR) est un composant d'une chaudière.

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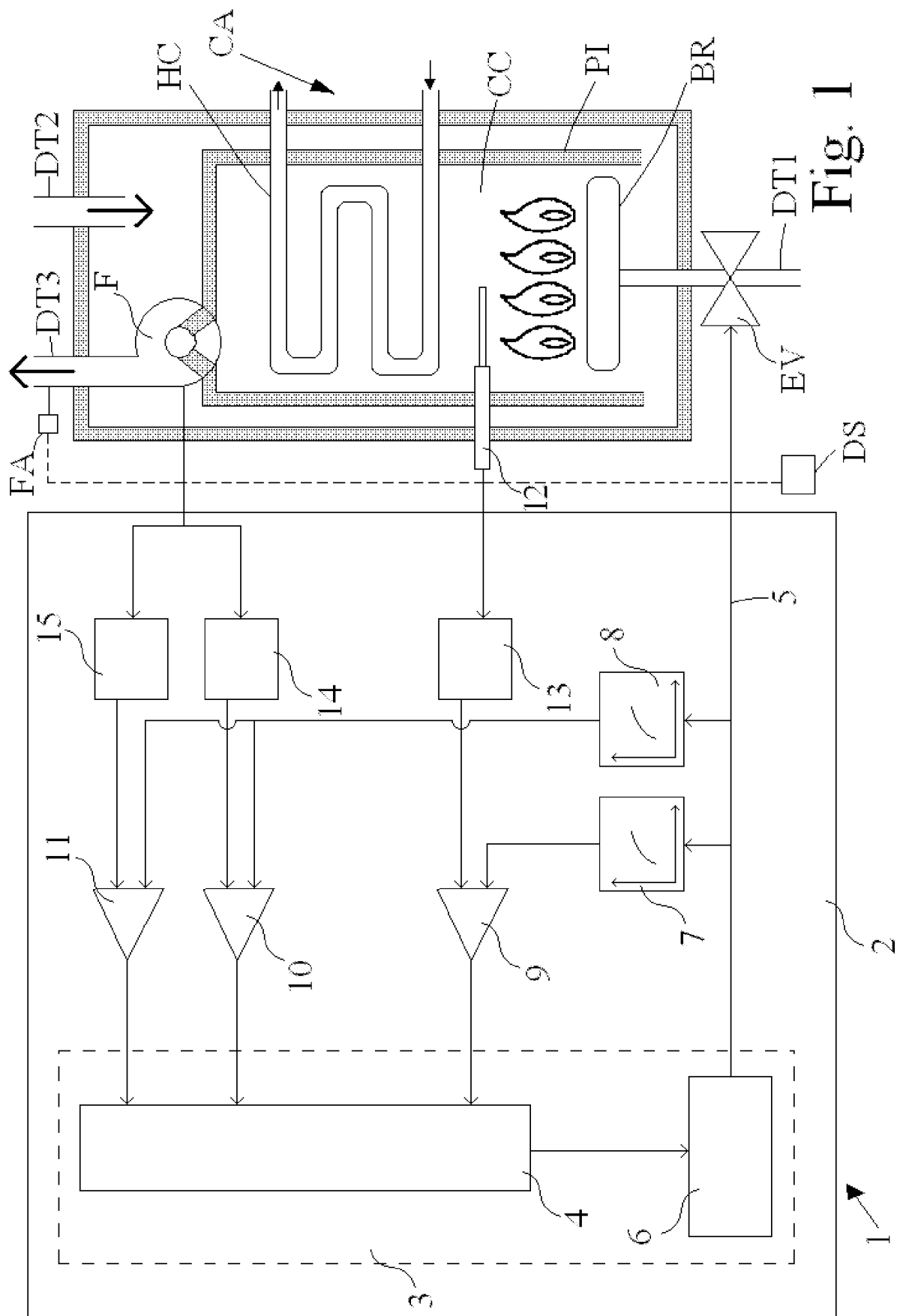


Fig. 1

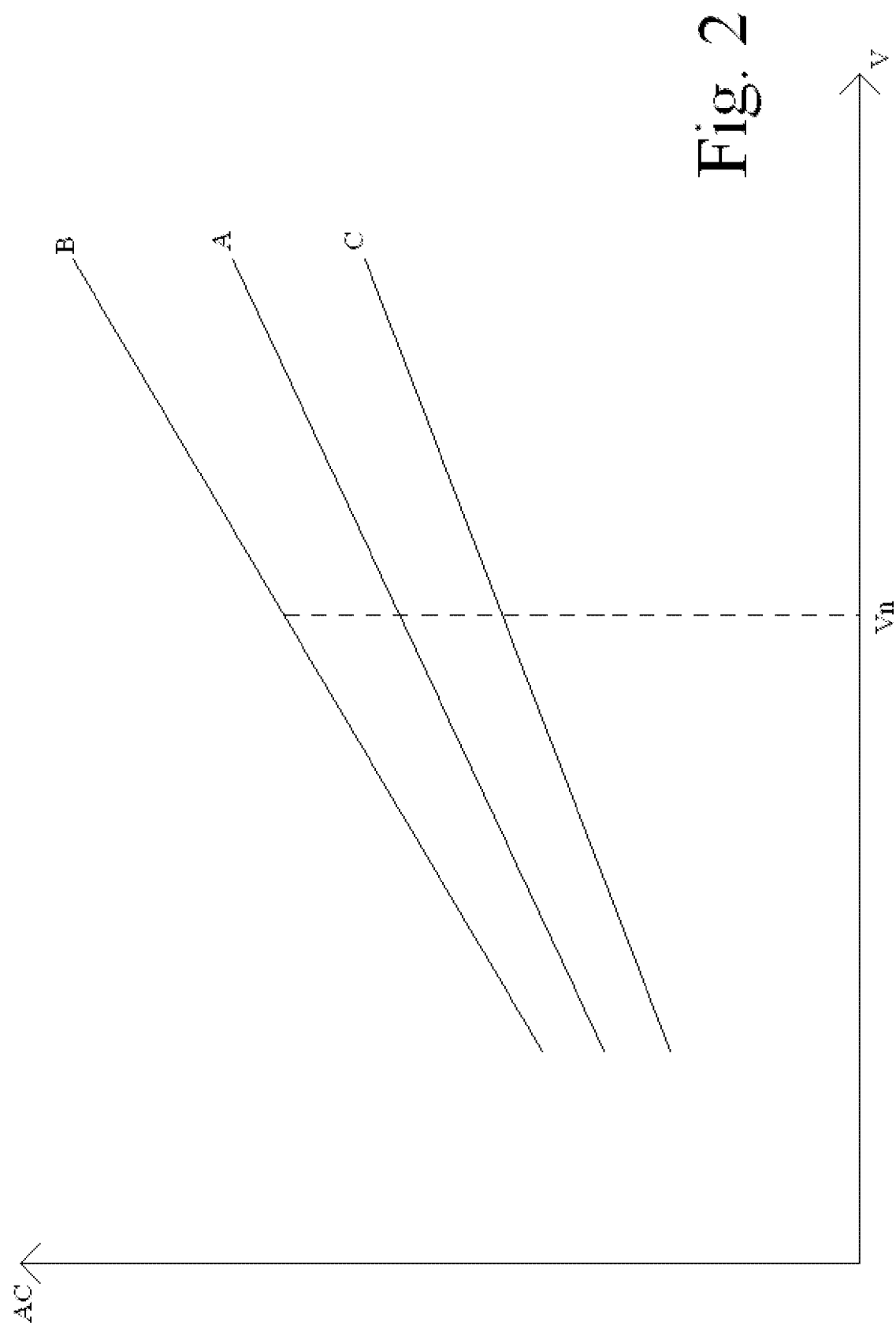


Fig. 2

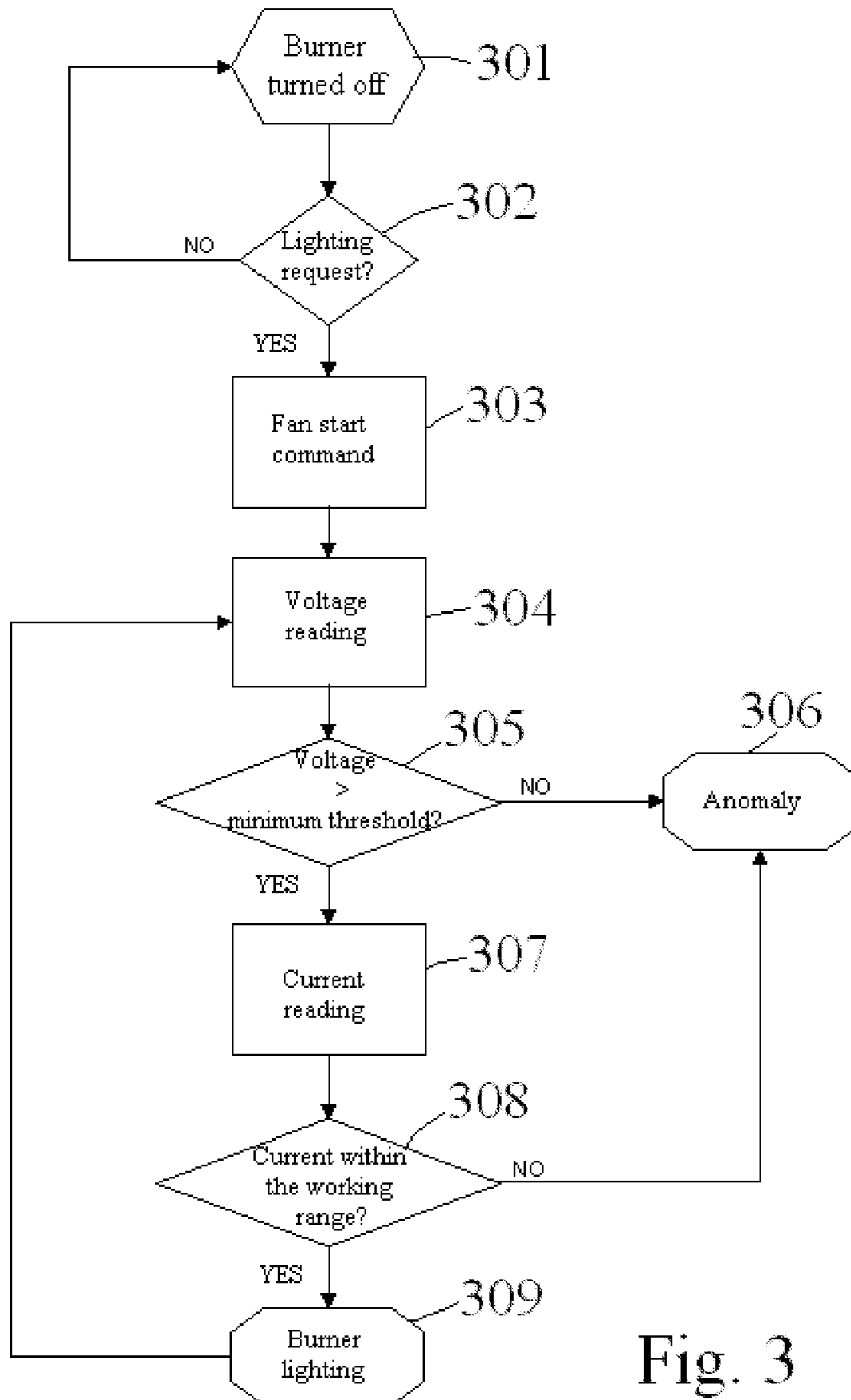


Fig. 3

Fig. 4

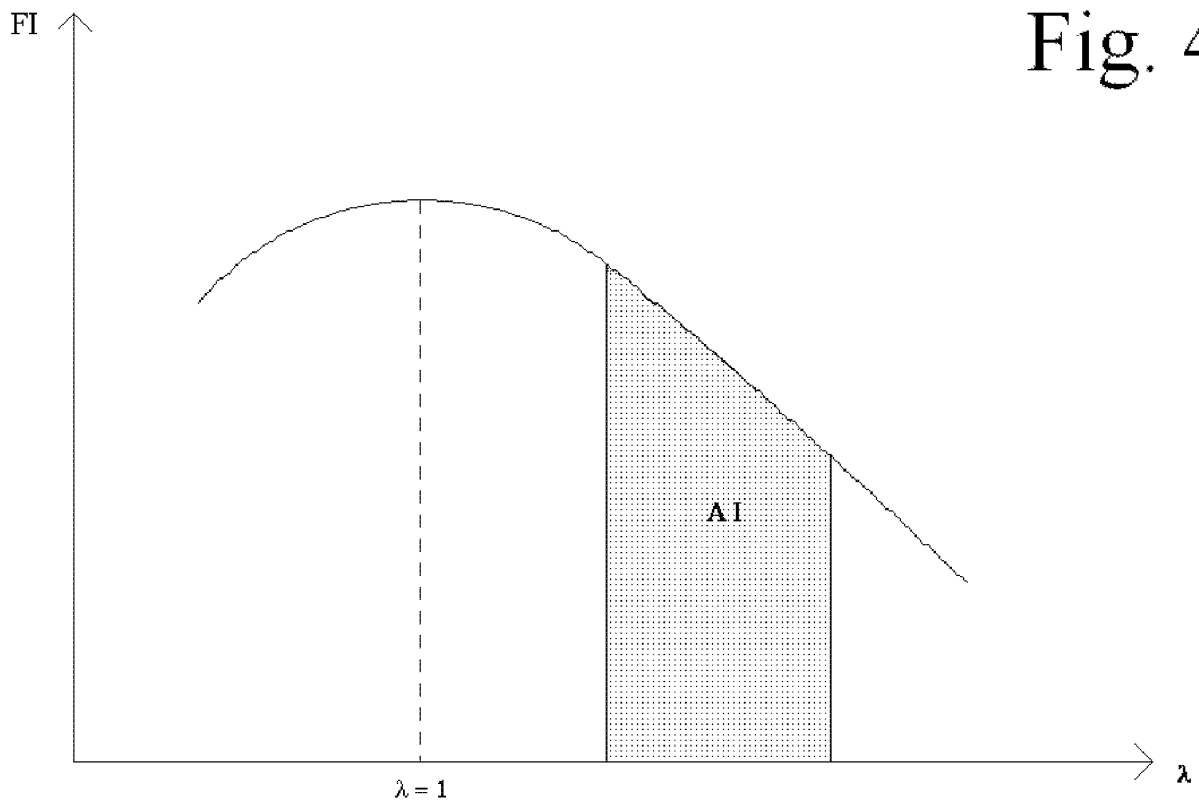


Fig. 5

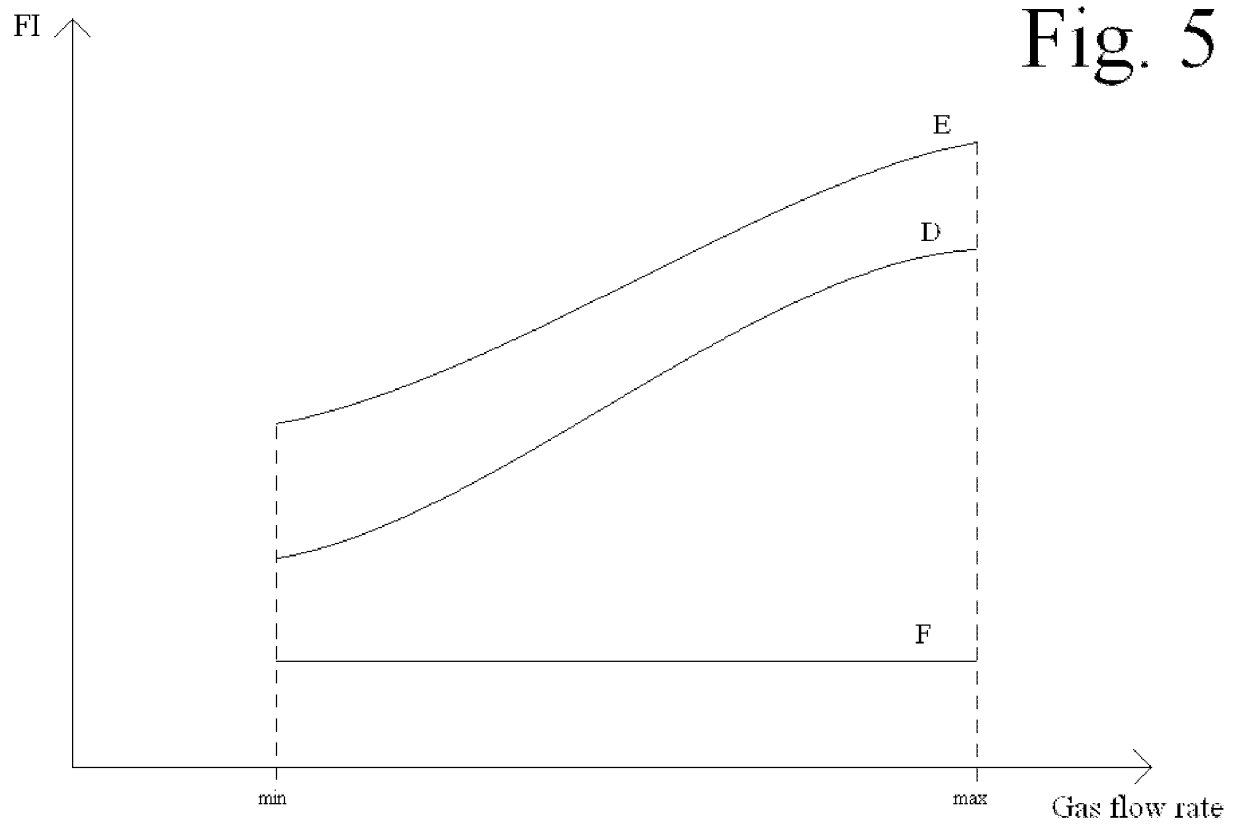


Fig. 6

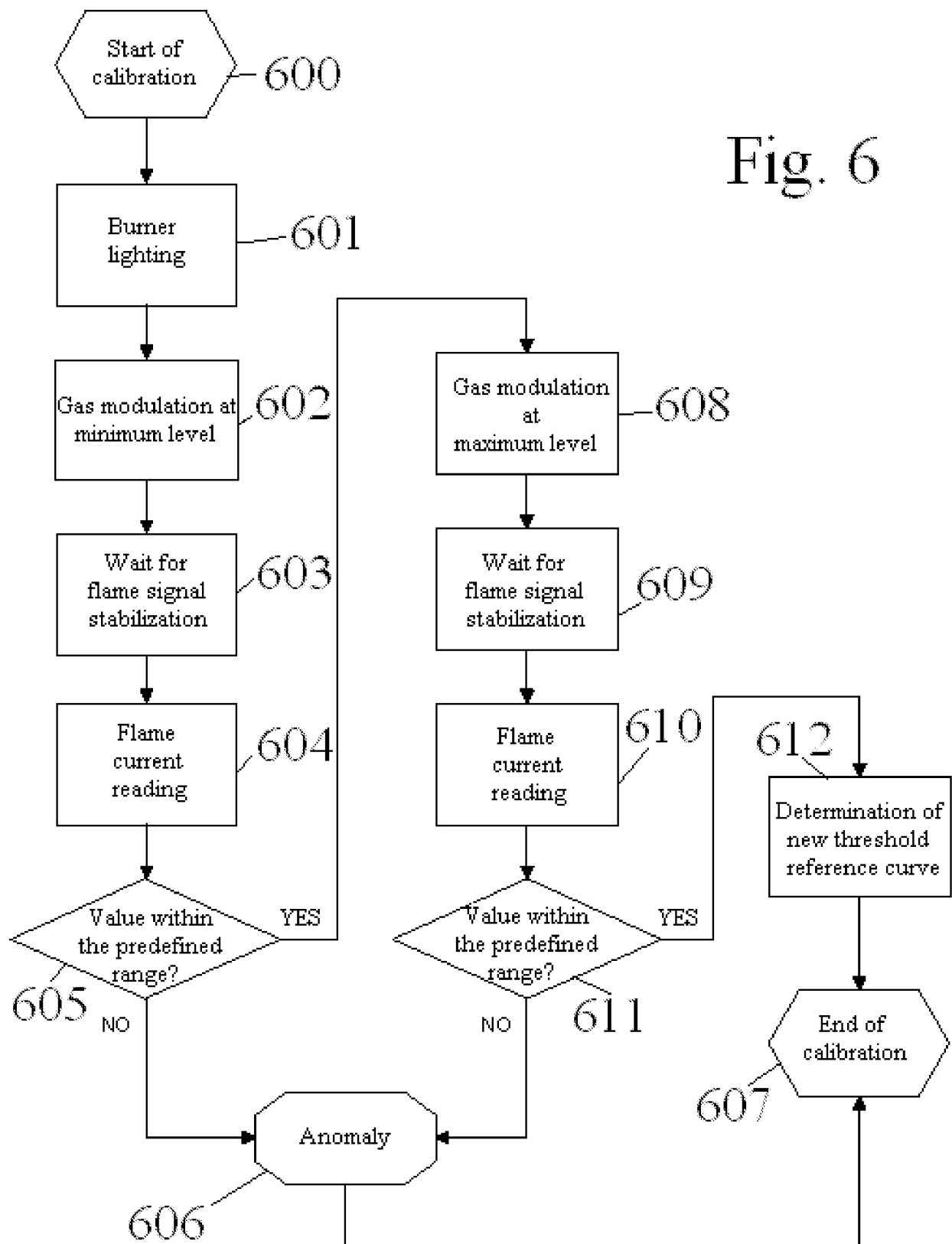
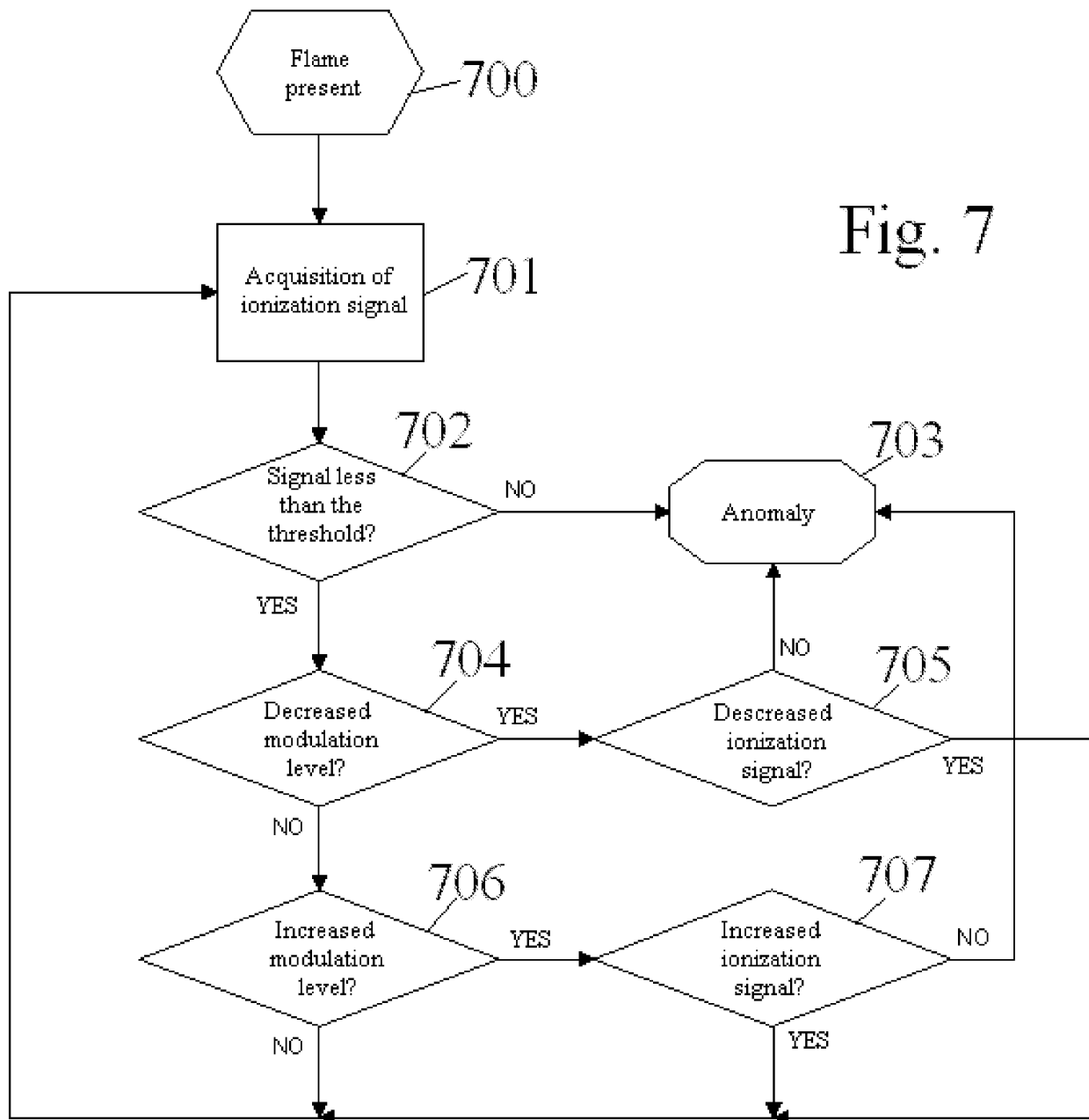


Fig. 7



REFERENCES CITED IN THE DESCRIPTION

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