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(54) Title: A METHOD FOR CONTROLLING A BURNER OF A BOILER AND A CONTROL SYSTEM OPERATING ACCORDING TO THIS METHOD

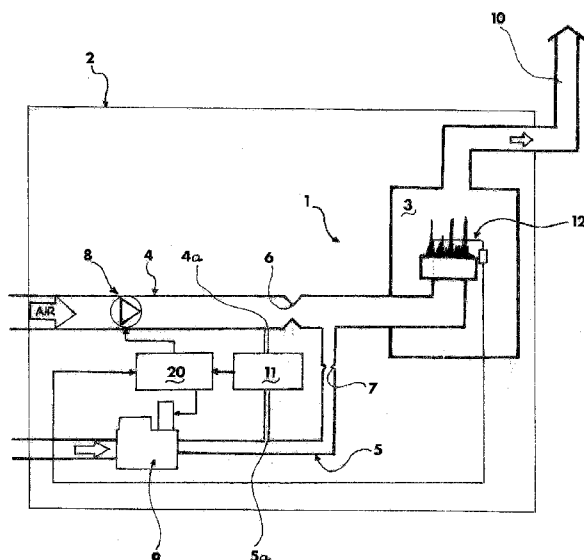


FIG.1

(57) Abstract: A method for controlling combustion in a burner (1) includes the steps of setting one of the first (8) and second (9) regulating means to a first setting value (n'); calculating, as a function of this first setting value, the optimal pressure difference ($\Delta P'$) between the first (4) and the second (5) conduit, corresponding to a desired ratio between the air flow and gas flow that is considered optimal for combustion; detecting the real pressure difference by means of the differential pressure meter (11), and regulating the other of the first and second regulating means so as to obtain a real pressure difference which is substantially equal to the optimal pressure difference. At predetermined time intervals, a step of automatic measurement of a percentage of obstruction of the flue (10) is carried out, in such a way that the optimal pressure difference is calculated taking into account for the variation with time of the resistance of the flue to the flow of spent gases.



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A METHOD FOR CONTROLLING A BURNER OF A BOILER AND A CONTROL SYSTEM OPERATING ACCORDING TO THIS METHOD

Description

Technical field

5 The present invention relates to a method for controlling a burner of a boiler, having the characteristics disclosed in the preamble of the main claim. It also relates to a control system operating according to this method.

Prior art

10 In the technical field in question, it is known that, in order to maintain efficient combustion, the ratio between the amount of air and the amount of combustible gas introduced into the burner must be kept in the proximity of a predetermined optimal level, which depends substantially on the type of gas used, and which, more generally, may also depend on the power supplied by the burner, that is to say on the gas flow rate.

15 This enables a complete combustion process to be achieved and maintained over time without excessive energy loss in the fumes and with minimal output of pollutant gases, in accordance with the regulations on emissions in a range of countries.

20 To meet this objective of maintaining the optimal air/gas ratio, various devices and methods have been developed in the technical field in question.

For example, there are known and widely used pneumatic control systems which control a gas regulation valve (for the purpose of achieving the optimal air/gas ratio) on the basis of a difference between the pressures present in the air supply conduit and the gas supply conduit respectively. However, devices of
25 this type are generally difficult to construct and rather inflexible in use.

Additionally, EP 1084369 discloses the control of a gas regulation valve for the purpose of achieving the optimal air/gas ratio on the basis of a flow measurement made in a conduit of suitable size extending in communication with the air and gas supply conduits.

5 Another regulation system, described in EP 281823, provides for the insertion, into the air conduit and gas conduit respectively, of flow meters capable of measuring the flow rate of the two fluids, thereby enabling the ratio of the fluids to be controlled directly.

However, this system requires the use of a measuring instrument for each fluid,
10 thus increasing production costs and the number of components in the system.

Description of the invention

The problem with which the present invention is concerned is that of providing a method for controlling a burner of a boiler, and a control system operating according to this method, which are structurally and functionally designed to
15 overcome the limitations described above with reference to the cited prior art.

Within the scope of this problem, one object of the invention is to provide a control method which is capable of ensuring optimal combustion throughout the range of flow rates for which the burner is designed, while avoiding the use of particularly costly components.

20 Another object of the invention is to propose a control method and system which are easily managed both during the installation of the boiler and in the course of subsequent modification or replacement of its components.

This problem is resolved and these objects are achieved by the present invention by means of a method and system for controlling a burner of a boiler,
25 realised in accordance with the following claims.

Brief description of the drawings

The characteristics and advantages of the invention will be made clearer by the following detailed description of a preferred embodiment thereof, illustrated, for the purposes of guidance and without limiting effect, with reference to the
5 attached drawings, in which:

- Figure 1 is a schematic view of a burner of a boiler having a control system operating according to the method of the present invention;
- Figure 2 is a graph showing the relations between the number of revolutions per minute of a fan of the burner of Figure 1, the air flow rate
10 produced by the fan, the gas flow rate required to obtain an optimal air/gas ratio for the combustion, and the pressure difference between the air and gas conduits in optimal combustion ratio conditions, the whole system being in a first condition of obstruction of the flue connected to the burner;
- 15 – Figure 3 is a graph similar to that of Figure 2, showing the relations between the same variables where there is a variation of the percentage of obstruction of the flue connected to the burner;
- Figure 4 is a simplified block diagram of a process for controlling the burner of Figure 1.

Preferred embodiment of the invention

20 In the drawings, the number 1 schematically indicates a burner which has a combustion control system constructed so as to operate according to the method of the present invention.

The burner 1 is housed in a boiler 2, for domestic or commercial use, preferably
25 intended for the production of domestic hot water and/or controlled by a space

heating circuit, in a known way which is not illustrated in the attached drawings. The burner 1 comprises a combustion chamber 3, which is supplied by a first conduit 4 and a second conduit 5, designed to send a flow of air and a flow of combustible gas, respectively, into the combustion chamber 3. Preferably, the
5 second conduit 5 opens into the first conduit 4 immediately upstream of the combustion chamber 3 (a "premix burner" arrangement).

A first measurement constriction 6 and a second measurement constriction 7, designed in such a way that the pressure drops in the corresponding conduits are predominantly concentrated at them, are provided in the first and second
10 conduits 4 and 5 respectively, before the junction of the two conduits.

The air is preferably introduced along the first conduit 4 by a fan 8, preferably positioned upstream of the first constriction 6, the impeller of the fan being rotatable at a controlled speed varying from about 0 to a maximum number of revolutions per minute ($n_{\max}$). Thus the fan 8 also forms the first means of
15 regulating the flow rate of the air introduced into the first conduit 4.

In alternative embodiments, the flow rate of the air introduced into the first conduit 4 can be varied by means of different systems.

On the other hand, the amount of combustible gas introduced into the combustion chamber 3 is varied by using second regulating means associated
20 with the second conduit 5, which preferably comprise a modulating valve 9, fitted in the second conduit 5 upstream of the second constriction 7.

The combustion chamber 3 is designed to be connected downstream to a flue 10, through which the spent combustion gases are discharged. The length and geometrical shape of the flue 10 are generally variable according to
25 circumstances. There may also be variations over time in the resistance of the

flue 10 to the spent gas flow, due to partial obstructions of its cross section, for example those caused by foreign bodies entering from outside or the accumulation of dirt along the flue.

The burner 1 further comprises a differential pressure meter 11 having one side
5 connected to the first conduit 4 at a point 4a upstream of the first constriction 6 and having its other side connected to the second conduit 5 at a point 5a between the second constriction 7 and the modulating valve 9.

If the fan 8 is located upstream of the first constriction 6, as in the preferred example described here, the point 4a is placed at an intermediate position
10 between the fan 8 and the first constriction 6. On the other hand, if the fan is positioned downstream of the first constriction 6, the point 4a will be upstream of both the first constriction 6 and the fan 8.

The differential pressure meter 11 preferably comprises an electrical strain gauge capable of converting small dimensional deformations, to which it is
15 subjected by the pressure difference present between the first and second conduit 4 and 5, into detectable electrical signals, without requiring a flow of fluid between the first and second conduit 4 and 5.

The electrical strain gauge is chosen in a suitable way so as to provide high sensitivity and a wide measurement range, thus ensuring adequate coverage of
20 the range of values within which the power of the burner 1 is regulated.

Accordingly, it is preferable for the first and second constrictions 6 and 7 to be designed in such a way that the pressure difference between the first and second conduits 4 and 5, in conditions of minimum air and gas flow (corresponding to the minimum operating power of the burner 1), is greater
25 than 1 Pa and preferably greater than 2.5 Pa.

The electrical strain gauge may be of either the conventional type or the semiconductor type (also known as a piezoresistive sensor). In the latter case, the strain gauge can be associated with a temperature control to compensate for any deviation of the measurement caused by a change in temperature.

5 Preferably, the electrical strain gauge is supplied with a pulsed voltage at a suitable frequency and level, so as to provide an adequate response signal for correct reading of the gauge, while avoiding any risk of damage to the electrical strain gauge.

In the combustion chamber 3 is also provided an electrode 12, positioned in the
10 flame in order to measure an ionization current of the flame. Thus, in the first place, the presence of the flame can be detected, and, secondly, the type of combustible gas used in the combustion can be determined.

The amounts of air and combustible gas introduced into the combustion chamber 3 are regulated by a control device 20 which is associated with the
15 differential pressure meter 11, with the electrode 12, and with the first and second means 8 and 9 for regulating the air and gas flow rates.

The control device 20 is designed to control the burner according to the method of the present invention, which is described in detail below.

The manufacturer stores the relations between the following variables in the
20 control device 20: the number of revolutions per minute of the fan 8 (n); the air flow rate in the first conduit 4 (Q_A); the optimal combustible gas flow rate in the second conduit 5 (Q_G); and the optimal pressure difference (ΔP) between the first and second conduit, as a function of the required thermal power and the type of gas used.

25 The graph in Figure 2 is an example of the way in which these relations can be

established for a specific gas. This graph shows a multiple graph in which the left half of the horizontal axis shows the number of revolutions of the fan per minute (n), the right half of the horizontal axis shows the volumetric flow rate of gas (Q_G), the lower half of the vertical axis shows the volumetric flow rate of air (Q_A), and the upper half of the vertical axis shows the pressure difference (ΔP).

In the lower left-hand quadrant of the graph of Figure 2, a curve A is shown, correlating the number of revolutions per minute n of the fan 8 with the air flow rate Q_A .

This relation is determined by the characteristics of the fan 8 and the geometrical characteristics of the conduit through which the air flows from its inlet to the outlet of the flue 10 (including the flow through the inside of the boiler), and can therefore be calculated precisely in controlled flue conditions, that is to say in conditions in which the flue has a known and definite geometry.

In particular, a preferred controlled flue condition is the flueless condition, in which case the pressure drop due to the flue is zero; this can be achieved in practice by disconnecting the combustion chamber 3 from the flue 10. In this case, the pressure drops of the air flow are substantially concentrated at the first constriction 6.

In the lower right-hand quadrant of the graph of Figure 2, a curve B is shown, correlating the air flow rate Q_A with the optimal combustible gas flow rate Q_G .

It is known that, in order to achieve correct combustion, there must be a specific volumetric ratio between the gas flow rate and the air flow rate, which substantially depends on the type of combustible gas.

For each type of combustible gas (or, similarly, for each mixture of combustible gases), it is therefore possible to determine a curve which correlates each value

of the air flow rate with the value of the gas flow rate which results in optimal combustion.

In practice, the optimal ratio between the air and gas flow rates is established as a specific percentage of excess air with respect to the stoichiometric ratio,
5 typically within the range from 110% to 130% of the stoichiometric ratio.

Consequently, in a first approximation at least, the curve B is found to have a substantially linear shape. Evidently, the same principle applies to non-linear relations between gas and air flow rates.

Furthermore, the burner 1 is generally designed to operate in a specific
10 operating range; in particular, it will only operate correctly if there is a minimum gas flow rate, and consequently this value, called Q_{Gmin} , is in fact predetermined and set.

The upper operating limit of the burner 1 is generally determined by the capacity of the fan 8, such that the maximum power of the burner 1 is obtained
15 at the value of n_{max} , which is also predetermined by the characteristics of the fan 8.

Additionally, since the curve B differs from one gas to another, the control device 20 is preferably made to store the curves for a plurality of gases or gas mixtures which are normally used as fuels in a burner of the type to which the
20 present invention relates.

The choice of the type of gas to use, that is to say the choice of the correct curve B to use, is made by analysing the ionization current detected by the electrode 12, using known methods such as those described in US 4645450, US 2004/0096789 and DE 3937290.

25 This type of analysis can be used to identify a given type of gas among a

plurality of gases stored in advance in a control device, and consequently to identify the correct curve B.

This analysis is conveniently carried out automatically at predetermined time intervals, appropriately chosen by the manufacturer.

5 In an alternative version of the control system of the burner 1, which is simpler and is not shown in the attached drawings, the selection of the combustible gas to be used (and consequently the setting of the operating curve B) can be carried out manually by an operator, for example at the time of installation of the boiler 2.

10 Finally, in the upper right-hand quadrant of the graph of Figure 2, a curve C is shown, correlating the optimal combustible gas flow rate Q_G with the pressure difference ΔP which is established between the first and the second conduit 4 and 5 when the air flow rate Q_A and the corresponding optimal gas flow rate Q_G are present in these conduits.

15 The pressure difference ΔP is determined unambiguously as soon as the geometrical characteristics of the conduits 4 and 5 are known.

This is because, if P_A and P_G are the air and gas pressures detected at the points 4a and 5a, and P_C is the pressure of the air/gas mixture at a point immediately downstream of the opening of the second conduit 5 into the first conduit 4, the
20 air and combustible gas flow rates can be found, respectively, from relations (1) and (2) below:

$$Q_A^2 = K_A \cdot (P_A - P_C) \quad (1)$$

$$Q_G^2 = K_G \cdot (P_G - P_C) \quad (2)$$

and therefore, since the optimal gas flow rate is linked to the air flow rate by a
25 specific relation, for example a linear relation (3):

$$Q_A = K_C Q_G \quad (3)$$

we find that:

$$\Delta P = (P_A - P_G) = Q_G^2 * (K_A^{-1} K_C^2 - K_G^{-1}) \quad (4)$$

Therefore, the pressure difference relative to the optimal gas flow rate, given a specified air flow rate, has a monotonically increasing quadratic shape, as shown by the curve C.

The operating range of the burner 1 is identified in the graph of Figure 2, being delimited below by the minimum gas flow rate required by the burner (Q_{Gmin}) and above by the maximum number of revolutions per minute of the fan 8 (n_{max}).

It will also be appreciated that the graph of Figure 2 enables the operating conditions for optimal combustion in the burner 1 to be identified unambiguously, starting from any of the variables represented.

For example, starting from a number of revolutions per minute n_1 , we find that the air and gas flow rates which provide optimal combustion are Q_{A1} and Q_{G1} , and that these flow rates create a pressure difference between points 4a and 5a equal to ΔP_1 .

As stated previously, the curves of Figure 2 are determined in controlled flue conditions, particularly in flueless conditions.

In real operating conditions, however, the presence of the flue 10 may be non-negligible, and in general its effect on the resistance to the flow of spent gases, and consequently to the flow of air and combustible gas, may vary over time.

In particular, the effect of non-negligible resistance at the flue 10 is manifested in a different curve A' which correlates the number of revolutions per minute n with the air flow rate Q_A .

The graph of Figure 3 shows various curves A' , A'' , A''' which correlate the number of revolutions per minute n of the fan 8 with the air flow rate Q_A as the percentage of obstruction of the flue 10 increases.

In particular, the curves A' , A'' , A''' exhibit a progressively smaller inclination relative to the horizontal axis, thereby redefining the operating range of the burner 1.

This is because, in order to provide the minimum gas flow rate required by the burner (Q_{Gmin}), there must be a number of revolutions per minute n higher than the value n_{min} which corresponds to the flueless condition, and, furthermore, by increasing the speed of the fan 8 to the maximum number of revolutions per minute (n_{max}) it is possible to obtain an air flow rate (and consequently a gas flow rate and a pressure difference) which is lower than that for the flueless condition.

Therefore, by the combination of these two effects, the operating range of the burner 1 is restricted overall as the percentage of obstruction of the flue increases.

This effect is clearly demonstrated by the following table, which shows the minimum and maximum numbers of revolutions of the fan (in rpm), the minimum and maximum air and gas flow rates (in m^3/h) in the optimal combustion ratio condition, and the consequent pressure difference (in Pa) between the points 4a and 5a, as the percentage of obstruction of the flue increases, represented in the graph 3 by the curves A , A' , A'' and A''' respectively.

Table 1

% flue obstruction	$n_{\min}$	$n_{\max}$	$Q_{A\min}$	$Q_{A\max}$	$Q_{G\min}$	$Q_{G\max}$	$\Delta P_{\min}$	$\Delta P_{\max}$
0	1000	6000	0.65	3.50	0.5	2.7	5	260
10	1100	6000	0.65	3.25	0.5	2.5	5	100
30	1600	6000	0.65	2.85	0.5	2.2	5	90
50	2500	6000	0.65	1.95	0.5	1.5	5	50

Conveniently, the control device 20 stores the relations between the number of revolutions per minute n of the fan 8 and the optimal pressure difference ΔP as the percentage of obstruction of the flue 10 varies, starting from the flueless condition up to a maximum percentage of obstruction, considered to be the maximum acceptable amount for which safe combustion can take place in the burner 1.

These relations can be stored in the control device 20 in the form of tables or in the form of mathematical functions, obtained if necessary by a process of fitting the discrete points defined by the table.

According to a first aspect of the present invention, therefore, the control system of the burner 1 operates by selecting the correct relation between ΔP and n , as a function of the percentage of obstruction of the flue 10.

For this purpose, the control system is made to carry out, at predetermined time intervals, a step of automatic measurement of the percentage of obstruction of the flue 10, according to the methods described in detail in the following paragraphs.

This step of measuring the percentage of obstruction of the flue is carried out by measuring the pressure difference between the points 4a and 5a, by means of

the electric strain gauge 11, in the absence of a gas flow (that is to say, with the modulating valve 9 fully closed) and with the fan 8 set to a predetermined value n_C .

Since the flow in the second conduit 5 is zero, the pressure difference measurement obtained in this way substantially corresponds to the pressure drop caused by the first constriction 6 to the air flow created along the first conduit 4.

This measured value is then compared with a table of values showing the pressure difference between the upstream and downstream ends of the first constriction 6 in conditions of different percentages of obstruction of the flue (starting from a flueless condition, up to a condition of maximum acceptable obstruction), in order to calculate the percentage of obstruction of the flue with which the burner 1 is required to operate.

This table of values is stored in advance in the control device 20, and can be produced by theoretical calculations or by appropriate experimental measurements conducted in controlled flue conditions, starting for example from a condition of a flue with a very large cross section (comparable to a flueless condition) and then progressively measuring the pressure drop caused by the first constriction 6 after successive controlled reductions of the flue cross section. Evidently, these measurements must be made while keeping the number of revolutions per minute of the fan 8 at the predetermined value n_C .

In an alternative method, the percentage of obstruction of the flue can be found on the basis of measurements of the pressure difference between points 4a and 5a, made using two or more predetermined values of the number of revolutions per minute of the fan 8, instead of the single predetermined value n_C .

On the basis of the percentage of obstruction of the flue found by the aforesaid comparison, the control device 20 selects the correct relation between ΔP optimal and n (in the form of a curve or table), on the basis of which it can then control the operation of the burner 1, first finding the lower limit of the operating range of the burner 1 determined by the minimum number of revolutions per minute ($n_{\min}$) required for the fan 8 to introduce a minimum flow of air and consequently gas into the combustion chamber, in accordance with the operating specifications of the burner.

The step of measuring the percentage of obstruction of the flue 10 is carried out, as stated above, at regular time intervals, in an automatic way, that is to say without the intervention of an operator.

This measurement can be made, for example, whenever the burner 1 is ignited, provided that the time taken for the measurement procedure is short enough, or when the burner 1 is ignited at the request of the heating circuit, when the speed of hot water production is less important. Alternatively, or additionally, the procedure of measuring the percentage of obstruction of the flue 10 can take place on a purely temporal basis, and may be independent of a request for burner ignition. For example, this measurement can be made at least once per day.

Preferably, the measurement of the percentage of obstruction of the flue not only allows the correct relation between ΔP optimal and n to be selected, but is also used to warn of a situation of excessive obstruction, requiring maintenance work on the flue, or, in the most serious cases, to cause the burner 1 to be extinguished because the conditions are not safe.

Purely by way of example, it is possible to make the control device 20 cause the

burner 1 to be extinguished, while sending a suitable alarm signal, when the percentage of obstruction of the flue exceeds a threshold of 50%, and to simply send a warning signal (while continuing with the burner ignition procedure) when the percentage of obstruction of the flue is between 30% and 50%.

- 5 When the correct relation between ΔP optimal and n has been determined, the control device 20 regulates the operation of the burner 1 according to the following procedures, shown in the block diagram in Figure 4.

When the boiler 2 receives a burner power request, transmitted for example by an ambient thermostat connected to the heating circuit, or from a domestic hot
10 water request, the control device 20 proceeds to set the number of revolutions per minute n of the fan 8 to a first setting n' , determined for example by the type of request received, while ensuring that this first setting n' is greater than $n_{\min}$.

As a function of the first setting n' , the control device calculates, on the basis of
15 the relation selected as a function of the percentage of obstruction of the flue, the optimal pressure difference $\Delta P'$ which is required between the first and second conduit 4 and 5 to keep the air and combustible gas flow rates in the correct ratio for optimal combustion.

At this point, the differential pressure meter 11 detects the real pressure
20 difference between the points 4a and 5a, and the control device 20 compares the real pressure difference with the optimal pressure difference $\Delta P'$, and then transmits a regulation signal to the modulating valve 9 to cause it to open or close so as to bring the real pressure difference to the optimal value of $\Delta P'$. This step of regulation of the modulating valve 9 takes place according to known PID
25 control procedures.

If the burner power request changes, the control device 20 sets a new value n'' of the number of revolutions per minute of the fan, and the step of regulating the modulating valve 9 described above is repeated to bring the measured pressure difference to the new optimal value $\Delta P''$.

- 5 At the end of the power request, the control device 20 causes the burner 1 to be extinguished.

In the preferred example described herein, the regulating means operated by the control device 20 to vary the pressure difference so as to bring it to the optimal value ΔP are represented by the modulating valve 9; however, the
10 operating principle could in theory be reversed, by setting an opening value in the modulating valve 9 and then regulating the number of revolutions per minute of the fan 8 to bring the pressure difference to the optimal value ΔP .

To enable the pressure difference between the points 4a and 5a to be measured correctly, the differential pressure meter 11 must be suitably calibrated.

- 15 Preferably, this calibration step can be carried out automatically by the control device 20, at the command of an operator, at the time of installation of the boiler and in the course of any subsequent repair and maintenance operations, for example after the replacement of the differential pressure meter.

The calibration step requires the measurement of a plurality of pressure
20 differences, for example ΔP_{11} , ΔP_{12} and ΔP_{13} , in the absence of a gas flow and in controlled flue conditions, preferably in flueless conditions, corresponding to a plurality of predetermined values, for example n_{11} , n_{12} and n_{13}),

The control device 20 then proceeds to calculate a transformation function for the pressure difference measured by the differential pressure meter 11 on the
25 basis of the comparison of measured pressure differences ΔP_{11} , ΔP_{12} and ΔP_{13}

with a corresponding plurality of pressure differences $\Delta P'_{11}$, $\Delta P'_{12}$ and $\Delta P'_{13}$ determined theoretically on the basis of the predetermined values of the number of revolutions per minute of the fan n_{11} , n_{12} e n_{13} .

On the basis of this transformation function, the measurements of the differential pressure meter 11, which are usually potentially subject to error, are converted to real pressure difference values by the control device 20.

Evidently, the comparison between the measured and theoretical values can be made on any suitable number of measurements.

The calibration procedure described above can be carried out automatically at the command of an operator, and simply requires the restoration of the controlled flue conditions in which the theoretical values $\Delta P'_{11}$, $\Delta P'_{12}$ e $\Delta P'_{13}$ were determined. These conditions are conveniently flueless conditions, in which case the boiler must be disconnected from the flue during the procedure.

Thus the present invention resolves the problem of the prior art identified above, while also offering numerous other benefits, including the use of inexpensive components and the constant monitoring of the state of obstruction of the flue.

CLAIMS

1. A method for controlling combustion in a burner (1) of a boiler (2), the burner comprising:

- a combustion chamber (3),
- 5 - a first conduit (4) having a first constriction (6), adapted to introduce air into the combustion chamber,
- first regulating means (8) associated with the first conduit (4), and designed to vary the quantity of air (Q_A) introduced into the first conduit,
- a second conduit (5) having a second constriction (7), adapted to
10 introduce a combustible gas into the combustion chamber,
- second regulating means (9) associated with the second conduit upstream of the second constriction, and designed to vary the quantity of gas (Q_G) introduced into the second conduit,
- a differential pressure meter (11) having one side (4a) connected to the
15 first conduit (4) upstream of the first constriction (6), and having its other side (5a) connected to the second conduit (5) between the second constriction (7) and the second regulating means, and
- a flue (10) through which the spent gases are discharged downstream of the combustion chamber,

20 the method comprising the steps of:

- setting one of the first and second regulating means to a first setting value (n'),
- calculating, as a function of the first setting value, the optimal pressure difference ($\Delta P'$) between the first and the second conduit, corresponding
25 to a desired ratio between the air flow and gas flow that is considered

optimal for combustion,

- detecting the real pressure difference by means of the differential pressure meter,
 - regulating the other of the first and second regulating means so as to
- 5 obtain a real pressure difference which is substantially equal to the optimal pressure difference,

and being characterized in that it includes, at predetermined time intervals, a step of automatic measurement of a percentage of obstruction of the flue, in such a way that the optimal pressure difference is calculated

10 taking into account the variation with time of the resistance of the flue to the flow of spent gases.

2. A method according to Claim 1, wherein the measurement of the percentage of obstruction of the flue is obtained by measuring the pressure difference in the absence of a gas flow and with the first regulating means (8) set to a
- 15 predetermined value (n_c).
3. A method according to Claim 2, wherein the pressure difference measured in the absence of a gas flow and with the first regulating means set to a predetermined value is compared with at least one value of pressure difference measured in controlled flue conditions.
- 20 4. A method according to any one of the preceding claims, wherein the measurement of the percentage of obstruction of the flue is performed at least once per day.
5. A method according to any one of the preceding claims, wherein the measurement of the percentage of obstruction of the flue is performed
- 25 immediately before the ignition of the burner.

6. A method according to any one of the preceding claims, wherein the first regulating means comprise a fan (8) with a variable number of revolutions per minute, wherein the minimum number of revolutions per minute ($n_{\min}$) of the fan which enables the burner to operate is determined on the basis of the measurement of the percentage of obstruction of the flue.
7. A method according to any one of the preceding claims, wherein the second regulating means comprise a modulating valve (9), the modulating valve being regulated as a function of the measurement of said pressure difference.
8. A method according to any one of the preceding claims, wherein the measurement of pressure difference is performed by means of an electrical strain gauge.
9. A method according to any one of the preceding claims, wherein a step of calibrating the differential pressure meter (11) is provided, comprising the steps of:
- measuring a plurality of pressure differences (ΔP_{11} , ΔP_{12} , ΔP_{13}) in the absence of a gas flow and in controlled flue conditions, corresponding to a corresponding plurality of predetermined setting values of the first regulating means (n_{11} , n_{12} , n_{13}),
 - calculating a transformation function for the pressure difference measured by the differential pressure meter on the basis of the comparison of the plurality of measured pressure differences (ΔP_{11} , ΔP_{12} , ΔP_{13}) with a corresponding plurality of pressure differences ($\Delta P'_{11}$, $\Delta P'_{12}$, $\Delta P'_{13}$) determined theoretically on the basis of the predetermined setting values of the first regulating means.

10.A method according to Claim 9, wherein the step of calibrating the differential pressure meter is carried out periodically.

11.A method according to Claim 9 or 10, wherein the step of calibrating the differential pressure meter is carried out in the absence of a flue.

5 12.A method according to any one of the preceding claims, wherein the first and second constrictions are designed in such a way that the optimal pressure difference, in the operating range of the burner, is greater than 1 Pa, and preferably greater than 2.5 Pa.

10 13.A method according to any one of the preceding claims, wherein the optimal pressure difference is calculated as a function of the type of combustible gas introduced into the combustion chamber.

14.A method according to Claim 13, wherein the type of combustible gas is determined by analysis of the ionization current in the flame in the combustion chamber.

15 15.A control system of the combustion in a burner (1) of a boiler (2), comprising:

- a combustion chamber (3),
- a first conduit (4) having a first constriction (6), adapted to introduce air into the combustion chamber,
- 20 - first regulating means (8) associated with the first conduit, and designed to vary the quantity of air introduced into the first conduit,
- a second conduit (5) having a second constriction (7), adapted to introduce gas into the combustion chamber,
- second regulating means (9) associated with the second conduit
- 25 upstream of the second constriction, and designed to vary the quantity

of gas introduced into the second conduit,

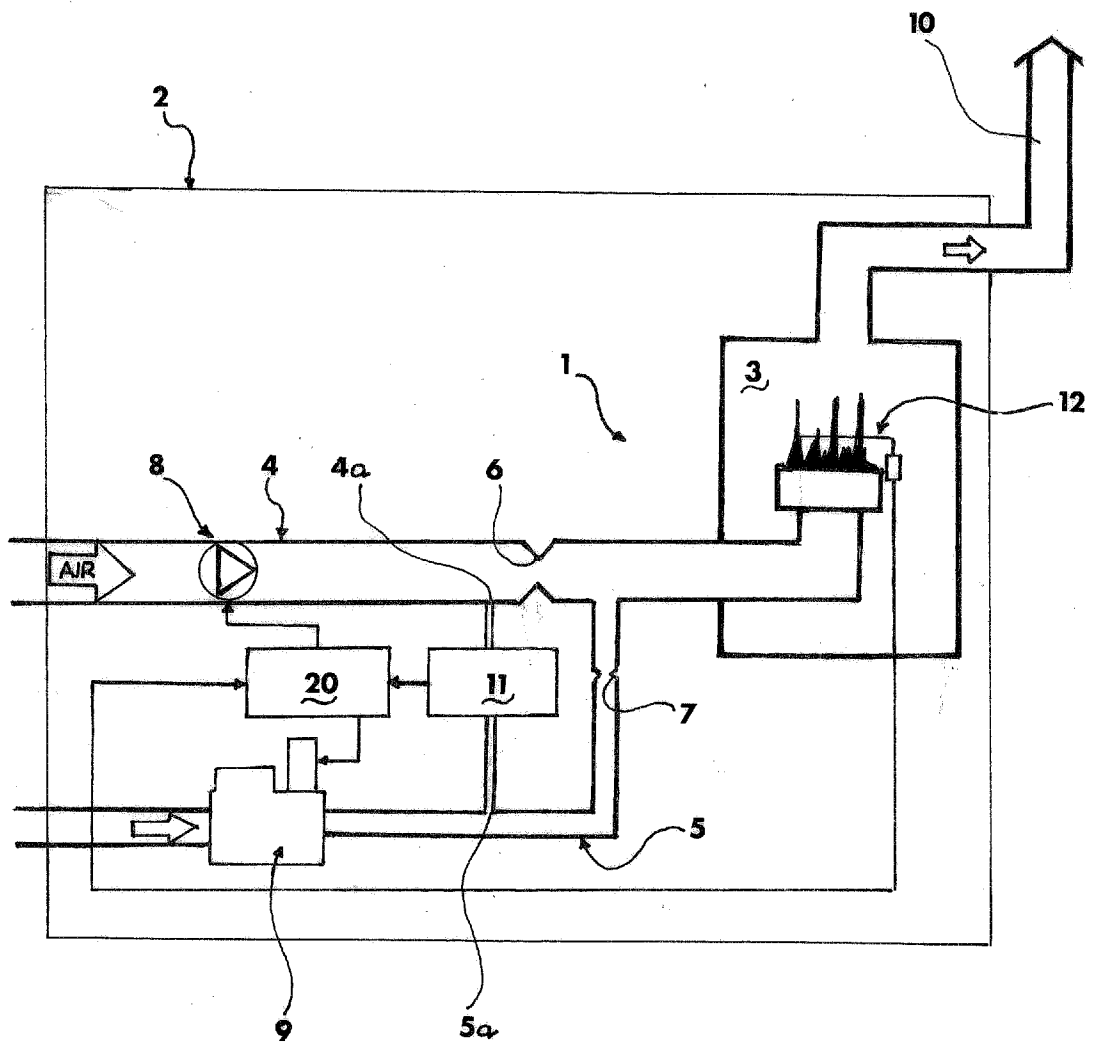
- a differential pressure meter (11) having one side (4a) connected to the first conduit upstream the first constriction, and having its other side (5a) connected to the second conduit between the second constriction and the second regulating means,
- a flue (10) through which the spent gases are discharged downstream of the combustion chamber,
- a control device (20) associated with the differential pressure meter to receive a signal correlated with a measured pressure difference, and associated with the first and second regulating means to operate one of the first and second regulating means on the basis of a comparison of the signal with an optimal pressure difference,

characterized in that the control device (20) is designed to calculate the optimal pressure difference as a function of a value set in the other of the first and second regulating means, and as a function of a percentage of obstruction of the flue; and in that it is designed to measure the percentage of obstruction of the flue automatically at predetermined time intervals.

16.A control system according to Claim 15, wherein the differential pressure meter (11) comprises an electrical strain gauge.

17. A control system according to Claim 16, wherein the first and second constrictions (6, 7) are designed in such a way that the optimal pressure difference is always greater than 1 P, and preferably greater than 2.5 Pa.

18. A control system according to Claim 16 or 17, wherein the electrical strain gauge is supplied with a pulsed voltage.

**FIG. 1**

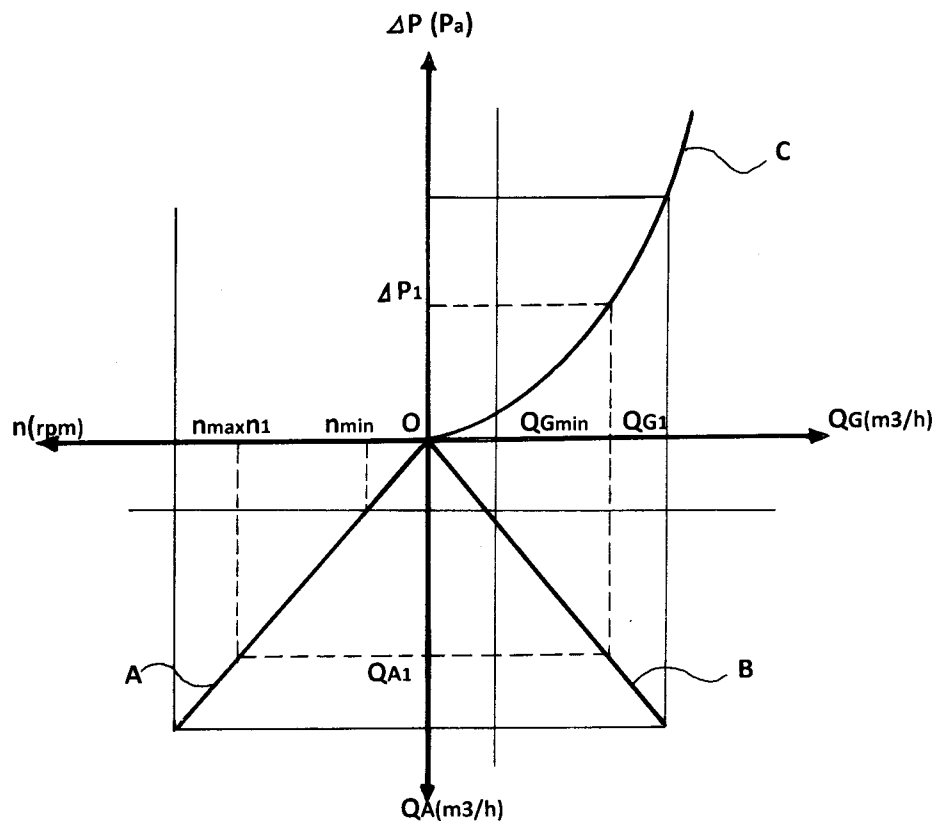


FIG. 2

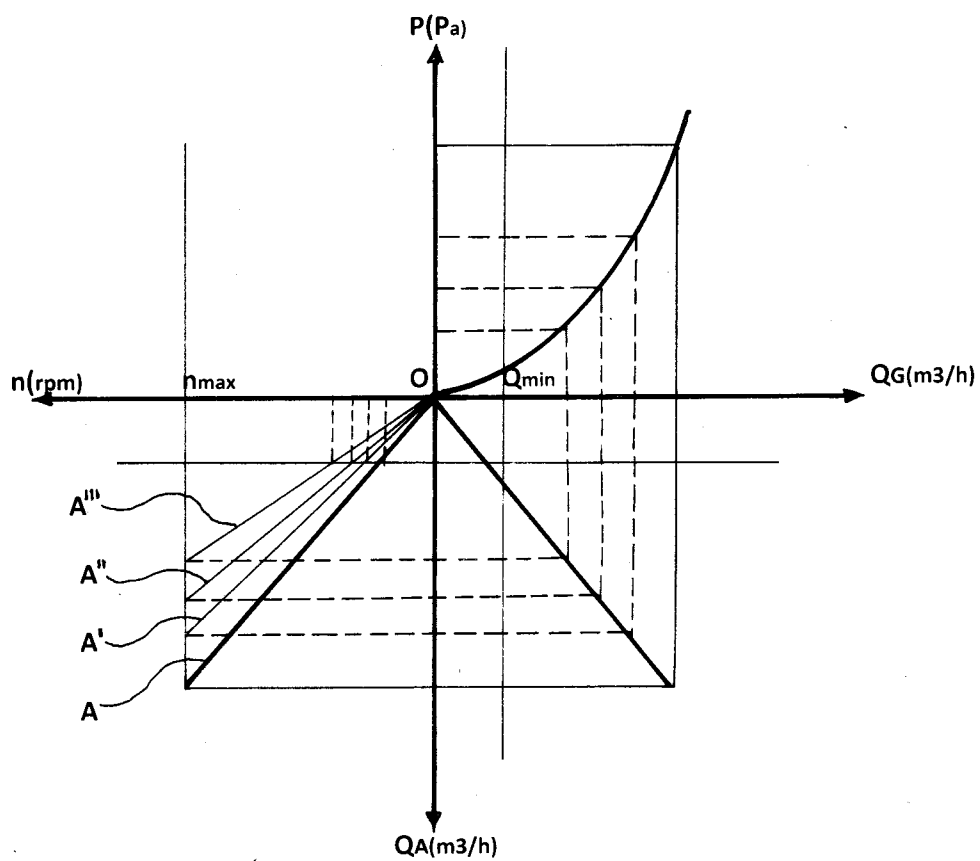


FIG. 3

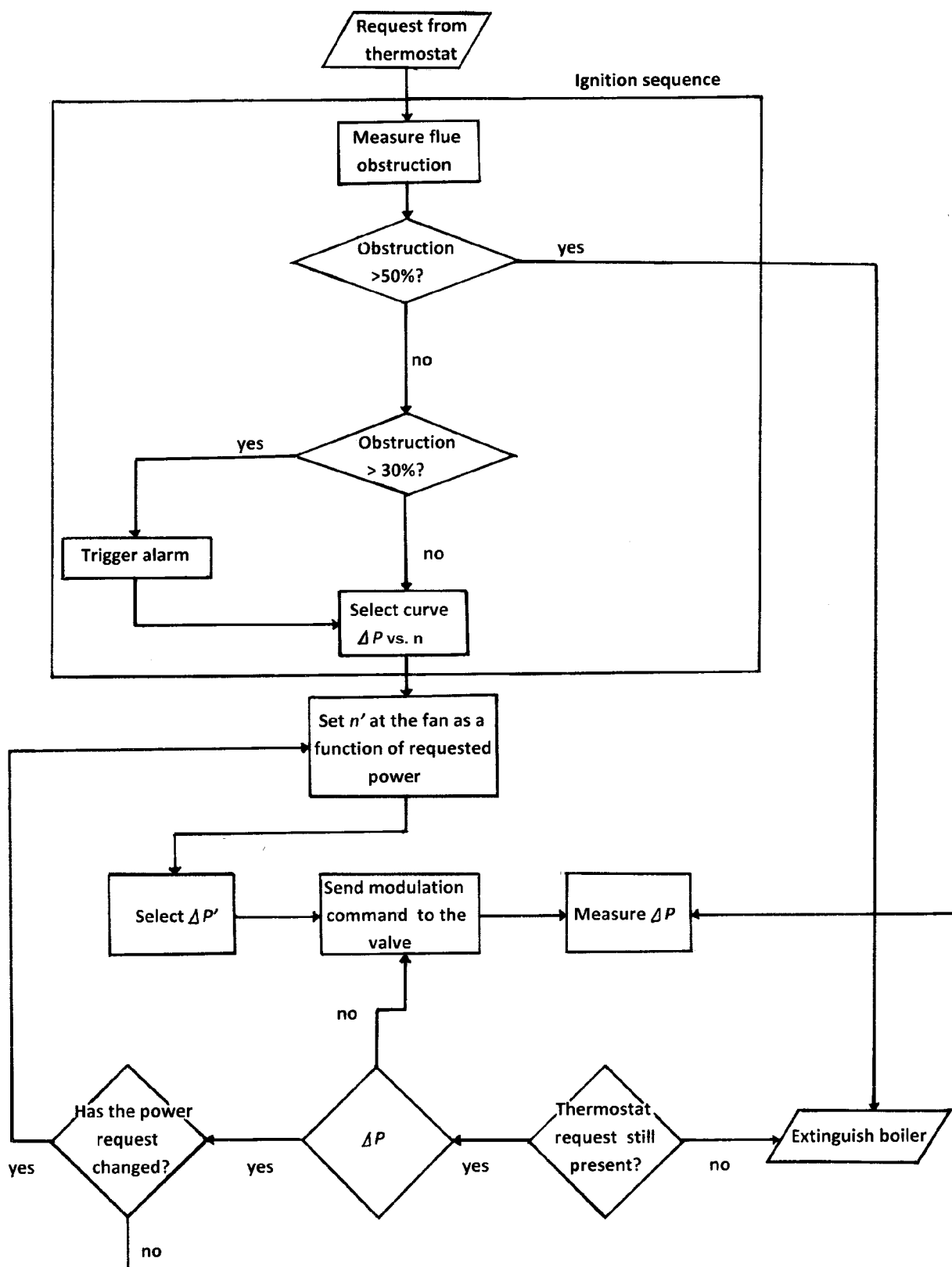


FIG.4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/052146

A. CLASSIFICATION OF SUBJECT MATTER

INV. F23N5/24 F23N1/02 F23N5/12
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F23N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	AT 510 002 A4 (VAILLANT GROUP AUSTRIA GMBH [AT]) 15 January 2012 (2012-01-15) page 5, last paragraph - page 6, last paragraph; figure 1 -----	1,15
A	EP 1 635 117 A1 (THEOBALD S A A [FR]) 15 March 2006 (2006-03-15) paragraphs [0011], [0012], [0021] - [0026], [0035] - [0050]; figure -----	1,15
A	EP 1 843 094 A1 (ECO HEATING SYSTEMS B V [NL]) 10 October 2007 (2007-10-10) paragraphs [0012] - [0027], [0030] - [0035]; figure 1 -----	1,8,15, 16
A	EP 1 084 369 B1 (HONEYWELL BV [NL]) 15 January 2003 (2003-01-15) cited in the application paragraph [0016]; figure 1 -----	1,15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

3 April 2013

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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