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

(57) A method for controlling the combustion of a burner (1) comprising an ignition step of the burner (1), a subsequent step of detecting a combustion value (*Iono*) representing a quality of the flame (4) and checking whether the detected *Iono* combustion value falls within a range of predefined values (*IonoMax* and *IonoMin*). The method comprises a step of switching off the burner

(1) if the combustion value (*Iono*) detected falls outside said range of the predefined values and of repeating the ignition step to vary the flow rate of the fuel according to an ignition ramp (5) and/or a predefined initial value (*ImodIgnMin*) that are different to the ignition ramp (5) and/or to the predefined initial value (*ImodIgnMin*) used during the preceding step of igniting the burner (1).

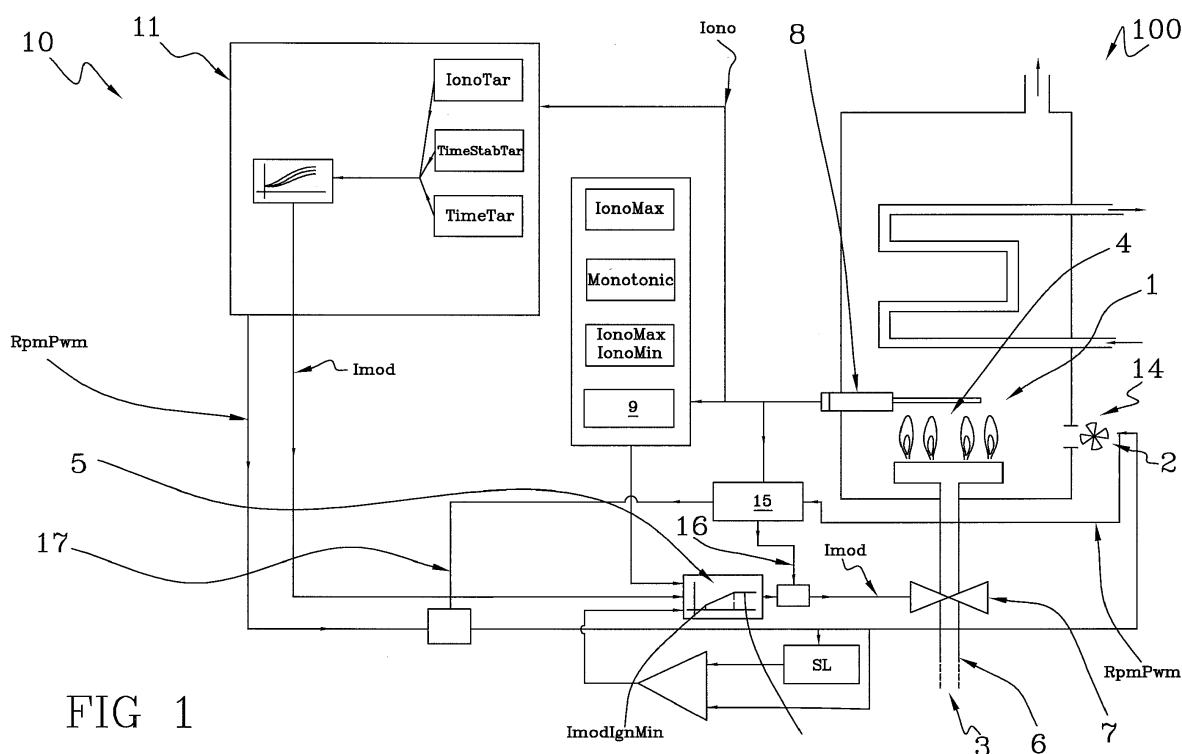


FIG 1

Description

[0001] The present invention relates to a method and a device for controlling the combustion of a burner for use in applications in which combustion is present. In particular, the present invention is used in atmospheric or premixed burners. The fuel is preferably in a gaseous or liquid state and is carried to the burner through a supply pipe.

[0002] Purely by way of example, a possible use of the burner according to the present invention is in the field of boilers for heating.

[0003] In the prior art, a common control device for combustion of a burner comprises:

- an on-off and modulating device (preferably a valve) which adjusts the fuel supply flow;
- supply means for supplying comburent active towards the burner for providing the comburent to the burner;
- detecting means of a presence of a flame associated, in use, to the burner (the detecting means being positioned at the flame position);
- means for detecting an ionization current representing a quality of the flame
- a control unit operatively connected to the on-off and modulating device, to the comburent supply means for controlling functioning thereof.

[0004] The comburent supply means preferably comprises a fan infeeding air. In other words, the comburent preferably comprises air, but might include any other type of comburent different to air.

[0005] In particular, it should be noted that the task of the control unit is mainly that of guaranteeing a "non-toxic" combustion so as not to generate spent gases (mainly carbon monoxide) damaging for the health of individuals. Still more in particular, this control is carried out by taking as a reference a curve in the ionization current realised as a function of the excess air index. It should be noted that the air excess index is, as is well known, defined by the ratio between the quantity of comburent air used and the quantity of air required for complete stoichiometric combustion and is indicated by symbol λ (lambda). The ionization curve is created on the basis of laboratory tests on the burner in a step preceding the installation of the burner at the final user's premises.

[0006] In this way, once the curve of the ionization current is known, during the functioning of the burner the value of the ionization current is measured (using the detecting means) and compared with a predefined threshold value (using the control unit) so as to control the combustion.

[0007] In particular, the control unit has the task of adjusting the quantity of air and gases supplied to the burner with the purpose of guaranteeing a correct combustion for each power value required by the user. For this purpose, in prior patent application WO 2014/140687 filed

in the name of the present applicant, a known control system of the combustion is described.

[0008] However, this control system has some drawbacks connected mainly to the fact that the quantity of air and gas supplied to the burner, in order to have a same power value, vary as a function of the type of gas present in the installation zone of the burner. In fact, more or less energetic gases exist in nature (G20, G25,...). A corresponding curve exists for each gas which links the flow rate of fuel to the power requested by the burner. Therefore, if the burner is used in a place where the gas on the basis of which the curve has been constructed is not available the control system does not work correctly.

[0009] In this situation, the object of the present invention is to realise a method and a device for controlling the combustion of a burner which obviates the above-cited drawbacks.

[0010] An aim of the present invention is to realise a method and a device for controlling the combustion of a burner which is able to automatically adjust to the type of fuel used.

[0011] Additionally, an aim of the present invention is to realise a method and a control device of the combustion of a burner which takes account of any eventual variations in variable parameters over time that are relative to the detection of the representative value of the quality of the flame.

[0012] The indicated aims are substantially attained by a method and a control device of the combustion of a burner according to what is described in the appended claims.

[0013] Further characteristics and advantages of the present invention will more greatly emerge from the detailed description of a preferred but not exclusive embodiment of a method and a device for controlling the combustion of a burner illustrated in the appended drawings, in which:

- figure 1 illustrates a device for controlling the combustion of a burner according to the present invention;
- figure 2 is a block diagram of the ignition step of the method according to the present invention; and
- figure 3 is a block diagram of the adjusting step of the method according to the present invention.

[0014] With reference to figure 1, the control method of the combustion of a burner 1 comprises at least a step of igniting the burner 1.

[0015] The step of igniting (figure 2) of the burner 1 comprises in turn a first substep of supplying the burner 1 with a predefined quantity of comburent. This predefined quantity of comburent is supplied to the burner 1 via the supply means 2 for supplying the comburent.

[0016] As mentioned in the foregoing, the comburent is preferably air and the supply means 2 for supplying the comburent comprises a fan 14.

[0017] In particular, the step of supplying the burner 1

with a predefined quantity of fuel includes switching on the supply means 2 for supplying comburent and keeping them switched on at least for a predefined initial time (also known as the pre-ventilation time) before supplying fuel to the burner 1 so as to operate a cleaning of the environment from the air surrounding the burner 1.

[0018] The step of igniting the burner 1 comprises, in turn, a second substep which includes activating flame ignition means 4 so as to be able to ignite the flame 4 in a subsequent step. The ignition means is configured for generating the igniting of the flame 4 on the burner 1.

[0019] The method preferably includes monitoring and controlling the energy of the ignition means with the aim of optimising the ignition. Still more preferably, the ignition means comprises a system (of known type and not being a part of the present invention) for generating a spark.

[0020] Precisely, in the specific and particular case of igniting by means of a spark, the energy of the ignition means is controlled by acting on the frequency, voltage and duration (defining the main characteristics) of the spark.

[0021] Additionally, the ignition of the burner 1 comprises a third substep which includes supplying a fuel to the burner 1 through a supply pipe 3 of the fuel.

[0022] The step of supplying the fuel to the burner is implemented by increasing the flow rate of said fuel starting from a predefined initial value *lmodlgnMin*.

[0023] In particular, said step of supplying the fuel to the burner is implemented by increasing a flow rate of said fuel according to a predefined ignition ramp 5 starting from a predefined initial value *lmodlgnMin* up until the flame is ignited so as to ignite the burner.

[0024] It should be noted that the step of supplying the fuel to the burner 1 is carried out by sending a command signal *lmod* to a fuel valve 7 interposed along the supply pipe 6. In other words, the command signal follows said predefined ignition ramp 5 starting from the predefined initial value *lmodlgnMin*.

[0025] At this point the flame ignition means 4 can be switched off.

[0026] Following the igniting of the burner 1, the method includes detecting a combustion value *lono* representing the quality of the flame using means for detecting 8 the quality of the flame operatively positioned at the flame. The combustion value *lono* is preferably defined by the ionization current of the flame 4. In other words, the detecting means 8 detects the value of the flame ionization current. The value of the flame ionization current depends on various factors among which also the flame temperature. Note that the combustion value *lono* is detected by means of a probe arranged at the flame 4 position, which generates a corresponding electric combustion signal.

[0027] Following the above, the method includes checking whether the flame ignition is normal or not. In particular, the flame ignition is defined as normal if:

- the combustion value *lono* detected in the moments immediately following the ignition of the flame is lower than a predefined maximum combustion value *lonoMax* (preferably this step is carried out in the very first moments following the ignition of the flame);
- the combustion value *lono* detected after the ignition of the flame is increasingly monotonic (this step is preferably carried out in the final moments of the ignition step);
- the detected combustion value *lono* falls within a range of predefined values *lonoMax* and *lonoMin* (preferably this step is carried out in the final moments of the ignition step).

[0028] In particular, the ignition step has a predefined duration *Timelgn* following which if the flame 4 has not ignited, the comburent supply and/or fuel supply is interrupted and the ignition step is repeated.

[0029] If the ignition is not normal, i.e. it does not satisfy at least one of the above-cited criteria, the method includes switching off the burner 1 by interrupting the comburent supply and implementing a re-ignition step which includes repeating the step of igniting the burner 1. This repeated ignition step is implemented by increasing the flow rate of said fuel according to an ignition ramp 5 and/or a predefined initial value *lmodlgnMin* that are different to the ignition ramp 5 and/or to a predefined initial value *lmodlgnMin* used during the non-normal step of igniting the burner 1.

[0030] For example, if no combustion value *lono* is detected, it is probable that the fuel used is not highly energetic and the predefined initial value *lmodlgnMin* of fuel flow rate is increased, as well as a predefined final value *lmodlgnMax* of said flow rate according to the ignition ramp 5.

[0031] In another case, if the combustion value *lono* detected has a behaviour that does not fall within the normal ignition conditions, it is probable that the fuel used is too energetic and the predefined initial value *lmodlgnMin* of fuel flow rate is reduced, as well as the predefined final value *lmodlgnMax* of said flow rate according to the ignition ramp 5.

[0032] It should be noted that the step of re-ignition is carried out following a step or a plurality of ignition steps that are not normal. In other words, the re-ignition step can be newly carried out if there has not been a normal ignition.

[0033] In a case of normal ignition, the method includes memorising the combustion value *lono* detected in a memory register 9 so as to create a historical record of the combustion values detected during the normal ignition step and with the aim of determining a reference point for a subsequent re-ignition.

[0034] When the non-normal ignition step has terminated, the combustion control immediately carries out the calibration step (figure 3) described in the following.

[0035] In a case of a normal ignition, the combustion control carries out the calibration step only if requested,

otherwise the adjusting step is immediately carried out, also described in the following.

[0036] The method further comprises a step of detecting a duration of the ignition step and comparing said duration with a predetermined ignition time *TimeIgn*; if the ignition of the flame 4 occurs after the predefined ignition time *TimeIgn*, the method includes implementing the re-ignition step. Further, the ignition step comprises a substep of detecting the flow rate value *RpmPwm* of the comburent supplied to the burner 1 and of comparing the flow rate value with a limit threshold value SL of a predefined comburent flow rate in such a way as to check whether the supplied flow rate value *RpmPwm* falls within the limit threshold SL or whether it exceeds the limit threshold SL.

[0037] If the supplied flow rate value falls within the limit threshold SL, the method includes proceeding with the subsequent step of activating the ignition means.

[0038] If the flow rate value *RpmPwm* supplied exceeds the limit threshold SL, the method comprises a step of modifying the ignition ramp 5 and/or the predefined initial value and/or the predefined final value *ImodIgnMax* used during the step of igniting the burner 1.

[0039] Further, the method comprises a calibration step (figure 3) performed following the ignition step. The calibration step comprises the following substeps:

- maintaining the predefined quantity of comburent after the ignition of the burner 1;
- increasing or decreasing the quantity of fuel supplied to the burner 1 in order to shift the combustion value *Iono* detected towards a predefined calibration combustion value *Iono*.

[0040] In particular, the calibration step is carried out:

- on each switching-on of the combustion control device (supply to the circuits);
- following a fault involving a shut-down of the burner 1;
- following a fault generated by the control device of the combustion itself;
- by a specific request of the control method during the adjusting step described in the following.

[0041] Additionally, note that the calibration step terminates when:

- the combustion value *Iono* detected reaches the predetermined calibration combustion value *IonoTar* and remains stable for at least a predetermined time *TimeStabTar*;
- a time phase required for performing this step is less than a maximum calibration time.

[0042] In particular, the calibration step is not completed in a case where the step is protracted beyond the maximum calibration time *TimeTar*.

[0043] In particular, the calibration step enables correcting the command signal *Imod* which is a function of the empirical curve of the combustion value *Iono* of the burner 1 determined by repeated laboratory tests with a predefined reference comburent (G20).

[0044] Further, the method comprises an adjusting step of maximum *ImodMax* and *ImodMin* minimum thresholds of the fuel flow rate value.

[0045] The adjusting step comprises the following substeps:

- maintaining the predefined quantity of comburent constant after the ignition of the burner 1;
- increasing or decreasing the quantity of fuel supplied to the burner 1 in order to maintain a same predefined combustion value *Iono*. The minimum threshold *ImodIgnMin* corresponds to the minimum quantity of comburent required for maintaining the same predefined combustion value *Iono*. The maximum threshold *ImodIgnMax* corresponds to the maximum quantity of comburent required for maintaining the same predefined combustion value *Iono*.

[0046] In other words, during the adjusting step, the control is carried out on the predefined combustion value *Iono* by adjusting the fuel flow rate.

[0047] In practice, the predefined combustion value *Iono* to be maintained and the corresponding fuel flow rate value are associated, instant by instant, to the detected comburent flow rate.

[0048] In any case, due to the preceding calibrating operation, the correction of the comburent flow rate value is reduced to a minimum.

[0049] In order to conserve the safety of the combustion control and therefore prevent the boiler from producing toxic fumes (CO), the combustion value *Iono* detected cannot vary externally of dynamic thresholds set by the control device.

[0050] Further, the method comprises a regulating step (figure 5) of detecting the combustion value *Iono*.

[0051] The regulating step can take place:

- at the end of a request for increase of heat from the control system of the combustion of the burner 1; or
- during the adjusting step, described in the foregoing.

[0052] During the regulating step a suitable algorithm acts to adjust the supply of fuel and comburent to the burner 1 in order to verify the correct functioning of the measurement of the combustion value *Iono*.

[0053] It should also be noted that the method of the present invention also comprises a first-installation routine which includes carrying out at least a calibration step and at least a regulating step as described in the foregoing.

[0054] In particular, the first-installation routine includes calculating an offset reference which is used by the combustion control. This offset reference takes ac-

count of the initial status of installation of the boiler, in relation to the place and type of installation. The offset reference is preferably calculated and memorised in a special memory unit 15 as a function of the contents of the combustion value *Iono* and the control signal *Rpm-Pwm* of the comburent supply means 2. Further, the memory unit 15 is configured for generating a modifying signal 16 for modifying the command signal *Imod* and a correcting signal 17 for correcting the control signal *Rpm-Pwm*. The first installation routine has an overall duration of a predetermined time during which the power of the boiler is adjusted by the combustion control.

[0055] Only at the end of the first installation routine can the boiler satisfy other heat-regulating requests.

[0056] The present invention further relates to a device 10 for controlling combustion of a burner 1. By way of example, figure 1 illustrates a boiler 100 comprising the burner 1. The control device 10 of the combustion comprises:

- on-off and modulating means 7 interposed along a supply pipe 6 for adjusting the fuel flow rate towards the burner 1. The on-off and modulating means 7 preferably comprises a control valve;
- supply means for supplying comburent 2 active towards the burner 1 for providing the comburent to the burner 1. The supply means 2 is modulable and preferably comprises a fan 14;
- flame ignition means associated, in use, to the burner 1;
- means for detecting a presence of a flame, which are operatively associated to the burner 1 for detecting a presence of a flame;
- detecting means 8 of a combustion value representing a quality of the flame 4. The means for detecting 8 preferably comprises a detector of the ionization current. Further, the detecting means is configured for supplying an output signal *Iono* representing the quality of the flame 4.
- a control unit 11 operatively connected to the on-off and modulating means 7, to the flame ignition means, to the comburent supply means 2 and to the detecting means.

[0057] The control unit 11 is in particular configured for:

- receiving the output signal from the detecting means of the combustion value *Iono*;
- sending control signals to the on-off and modulating means 7 and to the comburent supply means 2 for respectively controlling the fuel flow rate and the comburent flow rate.

[0058] In particular, the control unit 11 is programmed to carry out a sequence of operating steps according to what is described in the foregoing for the method, which is incorporated here in its entirety.

[0059] In detail, the control unit 11 is configured for:

- sending a control signal *RpmPwm* to the supply means for supplying the comburent 2 for start the supply means up at a predefined velocity *RpmIgn*;
- sending a control signal to the flame ignition means so as to be able to ignite the flame in a subsequent step;
- sending a control signal *Imod* to the on-off and modulating means 7 for increasing the passage of fuel according to a predefined ignition ramp 5 starting from a predefined initial value *ImodIgnMin* up until the flame is ignited so as to ignite the burner 1.

[0060] In the following, the control unit 11 is configured for receiving the output signal *Iono* representing the quality of the flame via the detecting means 8 of the quality of the flame and for verifying whether the value *Iono* detected falls within a range of predefined values *IonoMax* and *IonoMin*. In addition, the control unit 11 is configured for receiving the control signal *Imod* and for verifying whether the value *Imod* falls within a range of predefined values *IonoMax* and *IonoMin*.

[0061] If the combustion value *Iono* detected falls outside said range of predefined values and/or the control signal *Imod* falls outside the predefined values range *ImodMax* and *ImodMin*, the control unit 11 is configured for sending a control signal to the on-off and modulating means 7 for cutting off supply of fuel and for carrying out the re-ignition step which includes repeating the step of igniting the burner 1.

[0062] In particular, the control unit 11 is configured for carrying out the ignition step by sending a control signal *Imod* according to an ignition ramp 5 and/or a predefined initial value *ImodIgnMin* that are different to the ignition ramp 5 and/or to the predefined initial value *ImodIgnMin* used during the preceding step of igniting the burner 1.

[0063] The present invention attains the set aims.

[0064] In particular, the present invention enables adjusting the functioning of the burner to the type of gas which is used (more or less energetic gas). In fact, the ignition of the burner 1 is repeated until the flame ionization value settles at values retained suitable, via an increasing or decreasing of the ignition ramp 5 of the flame.

[0065] Further, for the type of gas used, the present system enables matching the whole representative curve of the ratio between the gas flow rate and the power requested by the boiler, also setting the respective upper and lower threshold curves within which the gas flow rate must be contained.

[0066] Also, worthy of note is that the present invention is relatively easy to realise and also that the cost connected to the actuation of the invention is not very high.

Claims

1. A method for controlling combustion of a burner (1),

comprising:

a step of igniting the burner (1) in turn comprising the following sub-steps:

- supplying a predefined quantity of comburent to the burner (1);
- activating flame ignition means so as to be able to ignite a flame (4) in a subsequent step;
- supplying a fuel to the burner (1) through a supply pipe (6) of the fuel; said step of supplying the fuel to the burner (1) being implemented by varying a flow rate of said fuel according to a predefined ignition ramp (5) starting from a predefined initial value (*ImodIgnMin*) up until causing the flame (4) to ignite so as to ignite the burner (1);

following the igniting of the burner (1), detecting a combustion value (*Iono*) representing a quality of the flame (4) using detecting means (8) of the quality of the flame (4) operatively positioned at the flame (4);

checking whether the detected combustion value *Iono* falls within a range of predefined values (*IonoMax* and *IonoMin*);

whether the combustion value (*Iono*) detected falls outside said range of predefined values, switching off the burner (1) by interrupting the supply of fuel and implementing a re-igniting step which includes repeating the step of igniting the burner (1); said repeated ignition step being implemented by increasing the flow rate of said fuel according to an ignition ramp (5) and/or a predefined initial value (*ImodIgnMin*) that are different to the ignition ramp (5) and/or to the predefined initial value (*ImodIgnMin*) used during the step of igniting the burner (1) in which the detected combustion value (*Iono*) fell outside the range of predefined values.

2. The method according to claim 1, **characterised in that** the step of checking whether the detected combustion value (*Iono*) falls within the range of predefined values is implemented after a predefined time period following the ignition of the flame.
3. The method according to any one of the preceding claims, **characterised in that** it comprises a step of comparing the combustion value (*Iono*) detected in the moments immediately following the ignition of the flame with a predefined maximum combustion value (*IonoMax*); said method including performing the re-igniting step if said combustion value (*Iono*) detected in the moments immediately following the ignition of the flame exceeds the predefined maximum combustion value (*IonoMax*).

4. The method according to any one of the preceding claims, **characterised in that** it comprises a step of checking the monotonicity of the combustion value (*Iono*) detected after the ignition of the flame; said method including carrying out the re-igniting step if said detected combustion value (*Iono*) is not increasingly monotonic.

5. The method according to any one of the preceding claims, **characterised in that** it comprises a step of detecting a duration of the ignition step and comparing said duration with a predetermined ignition time (*TimeIgn*); if the ignition of the flame occurs after the predefined ignition time (*TimeIgn*), the method includes implementing the re-ignition step.

6. The method according to any one of the preceding claims, **characterised in that** if the detected combustion value (*Iono*) falls within the range of predefined values, the method includes a step of memorising the detected combustion value (*Iono*) in a memory register (9) after the ignition of the flame.

7. The method according to any one of the preceding claims, **characterised in that** it comprises a step of detecting the flow rate value (*RpmPwm*) of the comburent supplied to the burner and of comparing the flow rate value with a limit threshold value (SL) of a predefined comburent flow rate in such a way as to check whether the supplied flow rate value falls within the limit threshold (SL) or whether it exceeds the limit threshold (SL).

8. The method according to claim 7, **characterised in that** it comprises a step of modifying the ignition ramp (5) and/or the predefined initial value (*ImodIgnMin*) used during the step of igniting the burner (1), if the supplied flow rate value exceeds the limit threshold (SL).

9. The method according to any one of the preceding claims, **characterised in that** it comprises a calibration step performed following the ignition step; said calibration step comprising following sub-steps:

- maintaining the predefined quantity of comburent after the ignition of the burner (1);
- increasing or decreasing the quantity of fuel supplied to the burner (1) in order to shift the detected combustion value (*Iono*) towards a predefined calibration combustion value (*Iono*).

10. The method according to claim (9), **characterised in that** the calibration step terminates when:

- the combustion value (*Iono*) detected reaches the predefined calibration combustion value (*IonoTar*) and remains stable for at least a pre-

determined time;

- a time phase required for performing this step is less than a maximum calibration time (*Time-Tar*).

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11. The method according to any one of the preceding claims, **characterised in that** it comprises an adjusting step of the maximum (*ImodIgnMax*) and minimum (*ImodIgnMin*) thresholds of the fuel flow rate value; said adjustment step comprising the following sub-steps: 10

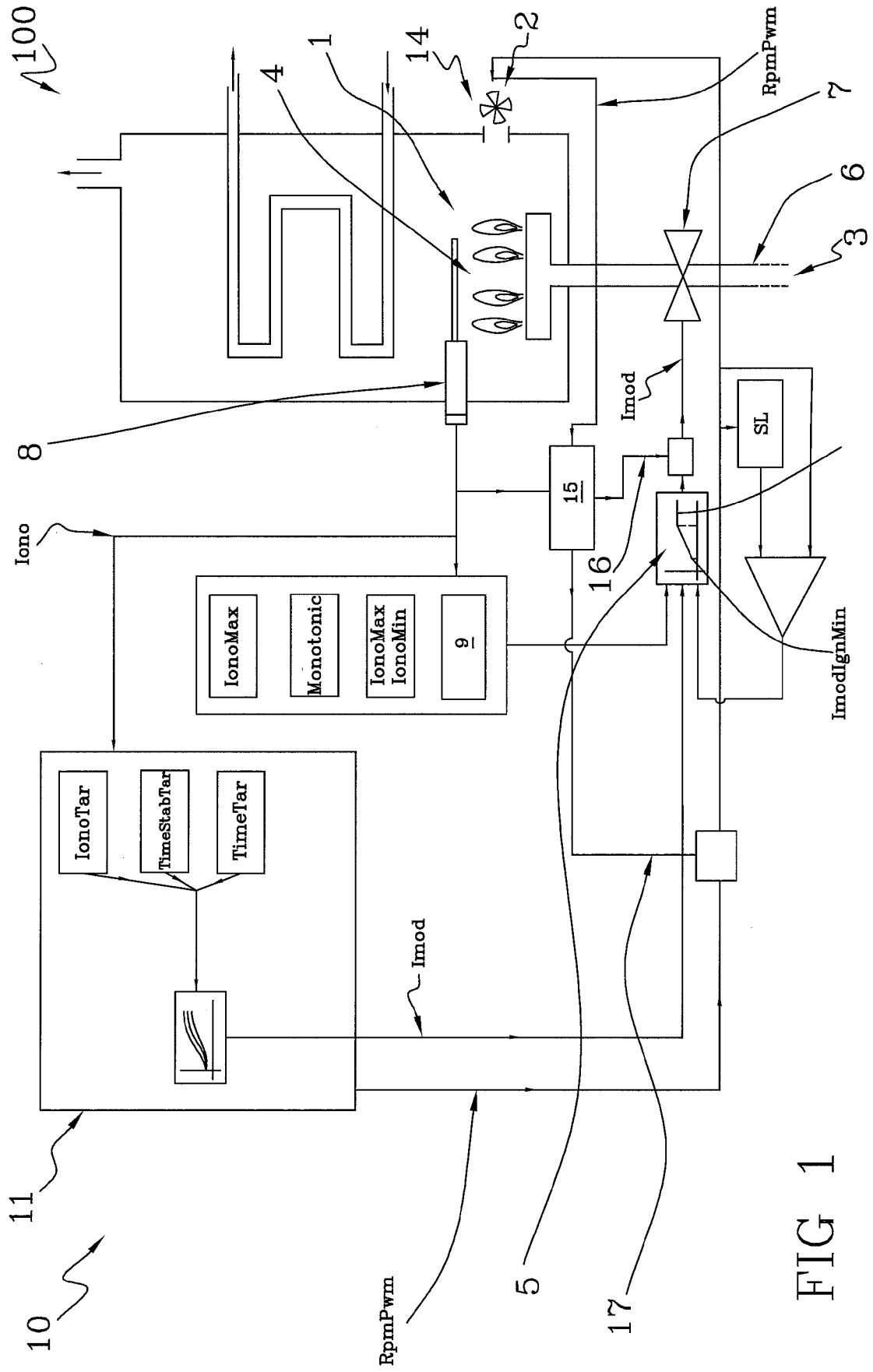
- maintaining the predefined quantity of comburent after the ignition of the burner (1);
 - increasing or decreasing the quantity of fuel supplied to the burner (1) in order to maintain a same predefined combustion value *Iono*; said minimum threshold (*ImodIgnMin*) corresponding to the minimum quantity of comburent required for maintaining the same predefined combustion value (*Iono*), said maximum threshold (*ImodIgnMax*) corresponding to the maximum quantity of comburent required for maintaining the same predefined combustion value (*Iono*). 15 20 25

12. The method according to any one of the preceding claims, **characterised in that** the step of detecting the combustion value (*Iono*) includes detecting the flame ionization current. 30

13. A device (10) for controlling combustion of a burner (1), comprising:

- on-off and modulating means (7) interposed along a supply pipe (6) for adjusting the fuel flow rate towards the burner (1); 35
 - supply means for supplying comburent (2) active towards the burner (1) for providing the comburent to the burner (1); 40
 - flame ignition means associated, in use, to the burner (1);
 - means for detecting a presence of a flame, which is operatively associated to the burner (1) for detecting a presence of a flame; 45
 - detecting means (8) of a combustion value (*Iono*) representing a quality of the flame;
 - a control unit (11) operatively connected to the on-off and modulating means (7), to the flame ignition means, to the comburent supply means (2) and to the detecting means; 50

characterised in that the control unit (11) is programmed to carry out a sequence of operating steps according to one or more of claims from 1 to 12. 55



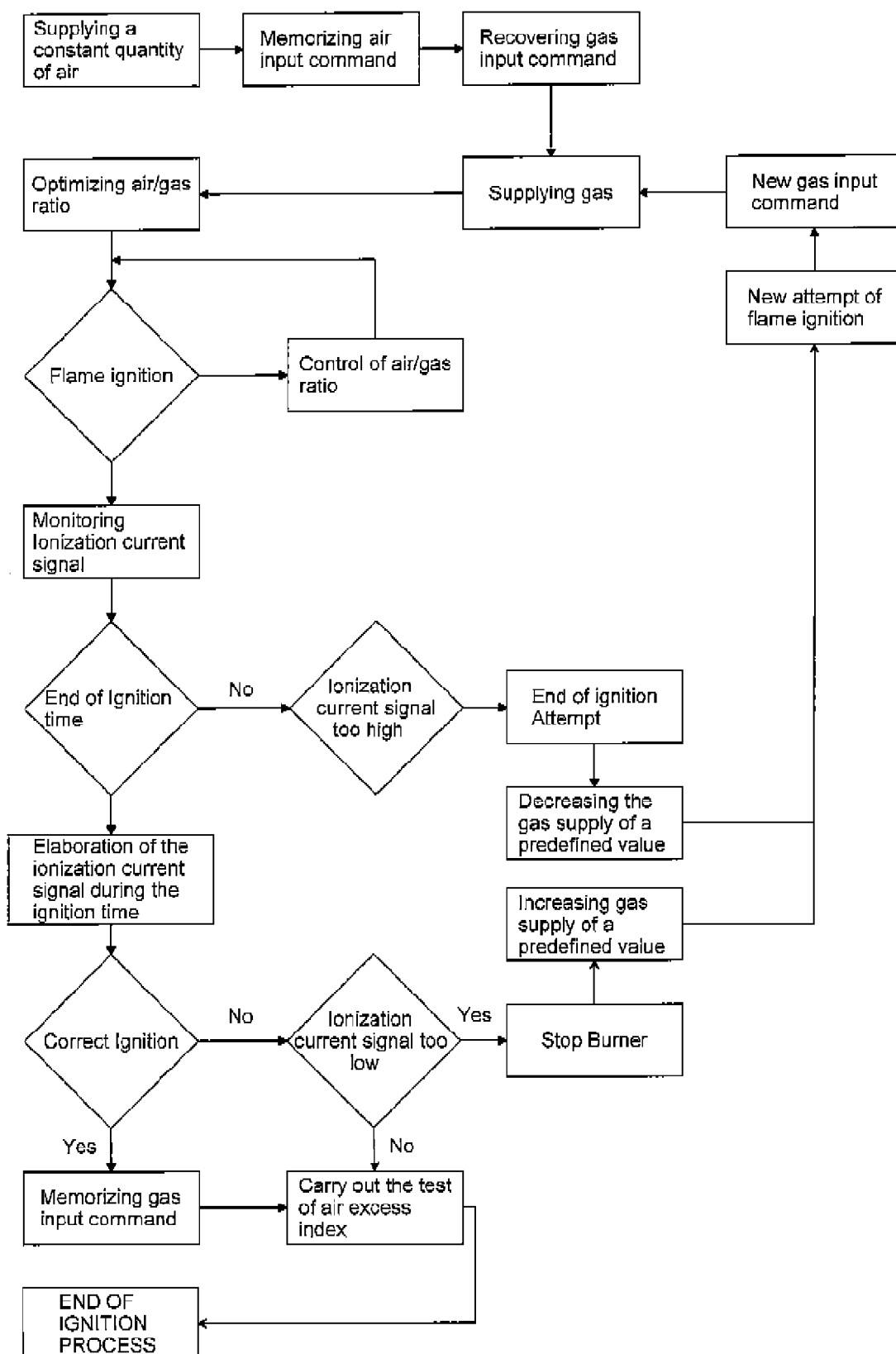


Fig. 2

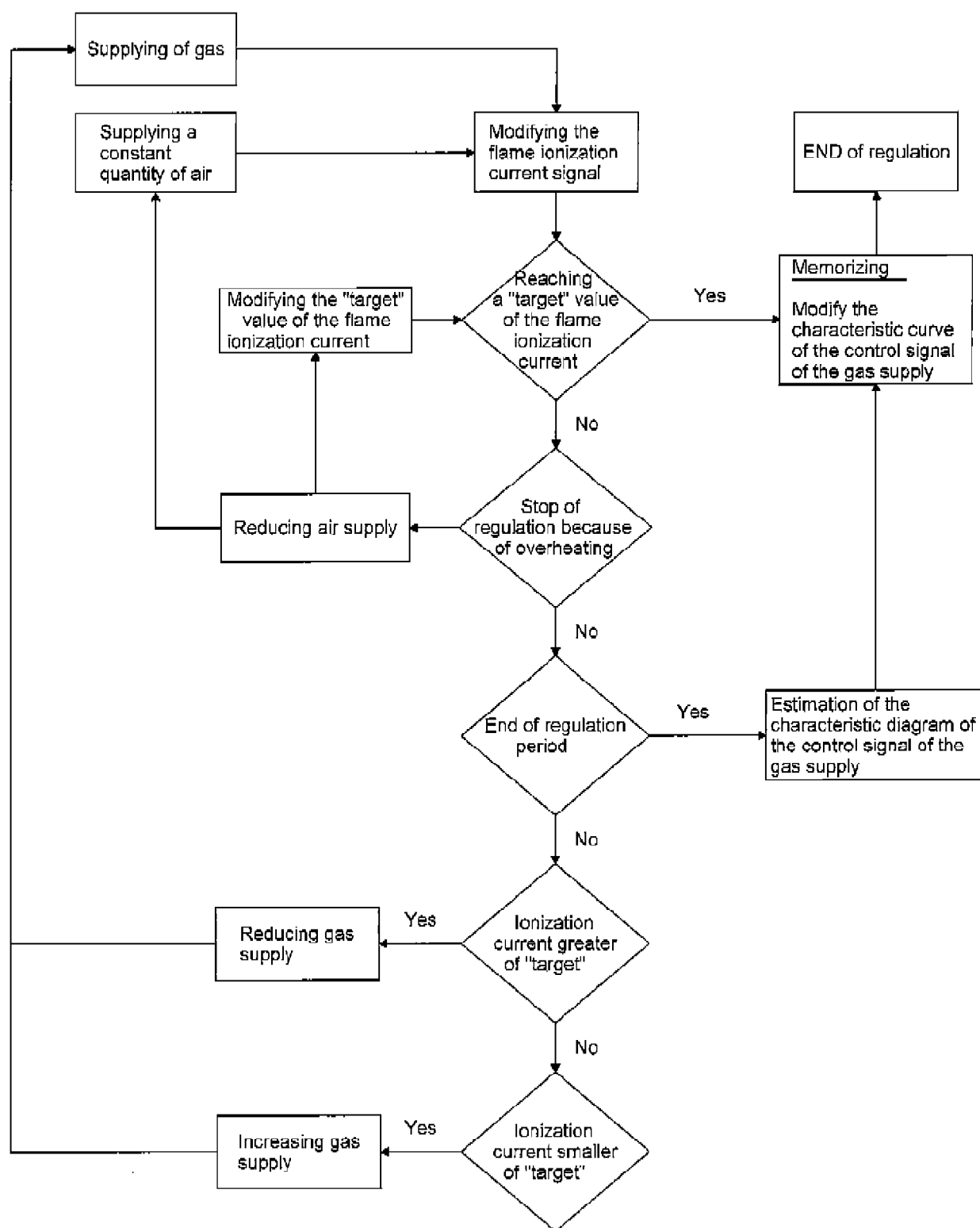


Fig. 3



EUROPEAN SEARCH REPORT

Application Number
EP 16 20 5815

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 27 April 2017	Examiner Rudolf, Andreas
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 16 20 5815

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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