(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 961 096 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
02.03.2022 Bulletin 2022/09

(21) Application number: **21191586.3**

(22) Date of filing: **17.08.2021**

(51) International Patent Classification (IPC):
F23D 14/02 *(2006.01)* ***F23D 14/72*** *(2006.01)*
F23N 5/24 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F23D 14/02; F23D 14/725; F23N 5/242;
F23C 2900/9901; F23N 2231/06; F23N 2231/28

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **28.08.2020 GB 202013599**

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(54) AN AIR-GAS MIXTURE BURNING APPLIANCE WITH A FLAME DETECTOR

(57) In an air-gas mixture burning appliance (100) that comprises an air-gas mixing unit (110) for mixing of air and gas to form a combustible air-gas mixture (130), a burning unit (120) with a burner surface (124) that is arranged downstream of the air-gas mixing unit (110) for burning the combustible air-gas mixture (130) at the burner surface (124), and a flame detector (150) for sensing presence of a flame (122) at the burner surface (124) on the basis of a predetermined flame detection threshold, the predetermined flame detection threshold is adjustable to vary for at least two different operating points of the air-gas mixture burning appliance (100).

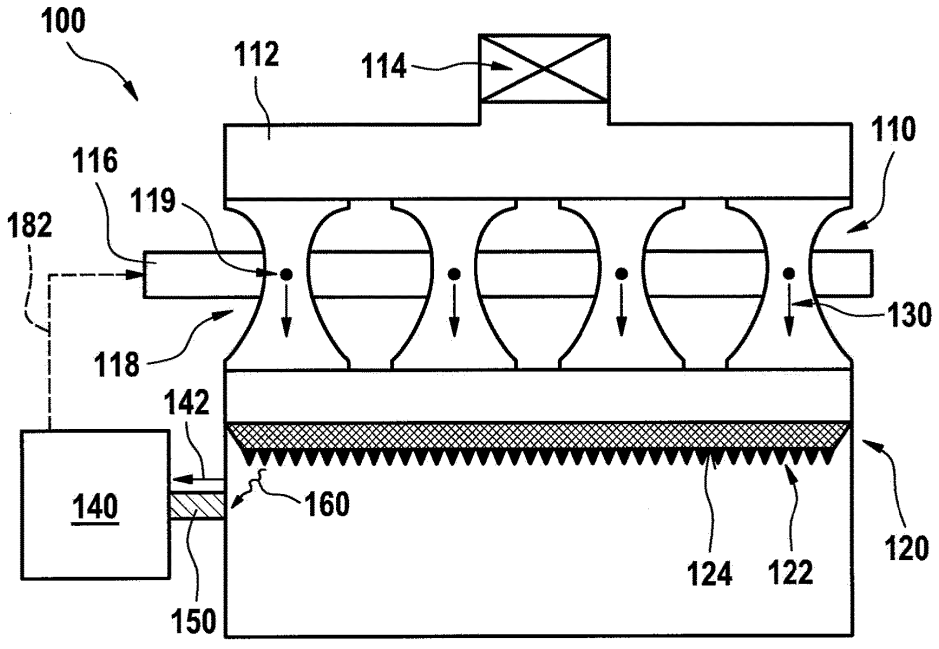

FIG. 1

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Description

Background of the Invention

[0001] The present invention relates to an air-gas mixture burning appliance that comprises an air-gas mixing unit for mixing of air and gas to form a combustible air-gas mixture, a burning unit with a burner surface that is arranged downstream of the air-gas mixing unit for burning the combustible air-gas mixture at the burner surface, and a flame detector for sensing presence of a flame at the burner surface on the basis of a predetermined flame detection threshold. Furthermore, the present invention relates to a flame detector for such an air-gas mixture burning appliance, as well as to a method of operating such an air-gas mixture burning appliance.

[0002] From the state of the art an air-gas mixture burning appliance with an air-gas mixing unit, a burning unit, and a flame detector is known. In this air-gas mixture burning appliance, hydrogen may be used as gas and mixed with air to form a combustible air-gas mixture.

[0003] More specifically, such an air-gas mixture burning appliance usually performs "just in time" mixing of air and gas directly before the burning unit to minimise a respective volume of combustible air-gas mixture available in the event of a flashback. Such a "just in time" mixing may be performed by means of discrete multiple mixers provided at the air-gas mixing unit. Thus, a predefined point of mixing for the air and gas may be located near an associated combustion space directly downstream of the burning unit.

[0004] If a flashback occurs, it is therefore possible that a flame may stabilise at the predefined point of mixing close to a burner surface of the burning unit. Furthermore, if the air-gas mixing unit comprises discrete multiple mixers, a flame may stabilise in one or more of the discrete multiple mixers upon occurrence of a flashback, while one or more other discrete multiple mixers may continue to provide combustible air-gas mixture to the burning unit, thus, supporting a residual flame on the burner surface.

[0005] In order to prevent flame stabilisation at the predefined point of mixing, flame detection for sensing presence of a flame adjacent to the burner surface may be performed. Therefore, a respective sensing element of the flame detector of the air-gas mixture burning appliance is usually positioned near the burner surface in order to acquire signals from the combustion space directly downstream of the burning unit. The flame detector determines whether a flame is well established at the burner surface with reference to a predetermined flame detection threshold.

[0006] The predetermined flame detection threshold is generally fixed and independent of any time-variant functional variables. More specifically, in order to ensure reliable flame detection of a flame at the burner surface of the burning unit and to avoid false "no flame" indications, the predetermined flame detection threshold that is applied to a sensed flame signal must be significantly smaller than a maximum value of a detectable flame signal given off by a normal flame stabilised against the burner surface. However, in order to avoid overheating of the air-gas mixing unit and unwanted noise in case of a flashback, the predetermined flame detection threshold must be significantly larger than a maximum value of a detectable flame signal given off by either one or more flames incorrectly stabilised at the predefined point of mixing, or a small residual flame on the burner surface of the burning unit of the air-gas mixture burning appliance, which is supported by the remaining unignited discrete multiple mixers.

[0007] In general, for an air-gas mixture burning appliance, a respective total volume of gas available to burn and an underlying flame length determine the maximum value of a detectable flame signal. The respective total volume of gas available to burn and the underlying flame length are both dictated by heat input and air-gas ratio.

Summary of the Invention

[0008] The present invention relates to an air-gas mixture burning appliance that comprises an air-gas mixing unit for mixing of air and gas to form a combustible air-gas mixture, a burning unit with a burner surface that is arranged downstream of the air-gas mixing unit for burning the combustible air-gas mixture at the burner surface, and a flame detector for sensing presence of a flame at the burner surface on the basis of a predetermined flame detection threshold that is adjustable to vary for at least two different operating points of the air-gas mixture burning appliance.

[0009] Advantageously, the inventive air-gas mixture burning appliance allows an improved flame detection at the burner surface of the burning unit by means of an adjustment of the predetermined flame detection threshold for at least two different operating points of the air-gas mixture burning appliance. More specifically, by adjusting the predetermined flame detection threshold for at least two different operating points, e.g. a detectable flame signal from a normal flame on the burner surface at a low firing rate of the air-gas mixing unit may reliably be recognised and distinguished from a detectable flame signal resulting from a sustained flashback at a high firing rate of the air-gas mixing unit. In this case, a conventionally predetermined flame detection threshold which is fixed and independent of any time-variant functional variables would either fail to detect the normal flame at the low firing rate, or fail to detect the sustained flashback at the high firing rate.

[0010] According to one aspect, the predetermined flame detection threshold is adjustable to avoid indication of a stable flame upon occurrence of a flame in the air-gas mixing unit under a sustained flashback event and/or in the event of a flame stabilising undesirably upstream of the burner surface.

[0011] Thus, overheating of the air-gas mixing unit and unwanted noise in case of a flashback may securely be

avoided.

[0012] Preferably, a predetermined discrete threshold value is assigned to each one of the at least two different operating points.

[0013] Accordingly, the predetermined flame detection threshold may reliably be adjusted between the predetermined discrete threshold values. Advantageously, the predetermined discrete threshold values may be selected to enable reliably detection of a normal flame stabilised against the burner surface whilst failing to allow the detection of a flame, in particular at the air-gas mixing unit, under a sustained flashback event.

[0014] According to one aspect, at least one of the at least two different operating points corresponds to an operating state of the burning unit or at least one operating parameter of the air-gas mixture burning appliance.

[0015] Thus, the predetermined flame detection threshold may advantageously be adjusted on the basis of a suitable time-variant operating state/parameter.

[0016] Preferably, the first operating state of the burning unit corresponds to an ignition phase of the burning unit, and a second operating state of the burning unit corresponds to a normal operating range of the burning unit.

[0017] Accordingly, a distinction between the ignition phase and the normal operating range of the burning unit may be made for a reliable and secure flame detection.

[0018] Preferably, a first predetermined flame detection threshold is associated with the first operating state of the burning unit, and a second predetermined flame detection threshold is associated with the second operating state of the burning unit, wherein the first predetermined flame detection threshold is smaller than the second predetermined flame detection threshold.

[0019] Thus, flame detection during the ignition phase and the normal operating range may easily be improved and adapted during operation of the burning unit.

[0020] Preferably, a first operating parameter of the air-gas mixture burning appliance corresponds to a first firing rate or a first range of firing rates of the air-gas mixing unit, or a first fan speed or a first range of fan speeds of a fan of the air-gas mixing unit, wherein a second operating parameter of the air-gas mixture burning appliance corresponds to a second firing rate or a second range of firing rates of the air-gas mixing unit, or a second fan speed or a second range of fan speeds of the fan.

[0021] Accordingly, a distinction between different firing rates or ranges of firing rates of the air-gas mixing unit, or between different fan speeds or ranges of fan speeds of the fan of the air-gas mixing unit may be made for a reliable and secure flame detection.

[0022] Preferably, a first predetermined flame detection threshold is associated with the first operating parameter of the air-gas mixture burning appliance, and a second predetermined flame detection threshold is associated with the second operating parameter of the air-gas mixture burning appliance, wherein the first predetermined flame detection threshold is smaller than the second predetermined flame detection threshold.

[0023] Thus, flame detection may be made dependent on varying operating parameters and easily be improved and adapted during operation of the burning unit.

[0024] According to one aspect, the at least one operating parameter corresponds to at least one of a firing rate, a range of firing rates, a fan speed, a range of fan speeds, an air-gas ratio or a range of air-gas ratios.

[0025] Thus, various different operating parameters may be used for adjustment of the predetermined flame detection threshold.

[0026] Preferably, the predetermined flame detection threshold is associated with, and adjusted based on, the at least one operating parameter.

[0027] Accordingly, the predetermined flame detection threshold is not restricted to simply switching between two discrete flame detection thresholds, but will advantageously switch continuously depending on one of: the firing rate, range of firing rates, fan speed, range of fan speeds, air-gas ratio or range of air-gas ratios.

[0028] According to one aspect, the air-gas mixture burning appliance further comprises a controller that is connected to the flame detector and adapted to control supply of gas to the air-gas mixing unit on the basis of a detection signal provided by the flame detector.

[0029] Thus, the gas supply to the air-gas mixing unit may advantageously be made dependent on the detection signal provided by the flame detector.

[0030] Preferably, the controller is adapted to interrupt supply of gas to the air-gas mixing unit if the detection signal indicates an abnormal flame state at the burner surface.

[0031] Accordingly, the supply of gas to the air-gas mixing unit may be interrupted safely and securely if the detection signal indicates the abnormal flame state at the burner surface.

[0032] According to one aspect, the gas is hydrogen.

[0033] Thus, the air-gas mixture burning appliance may advantageously be embodied as an air-hydrogen mixture burning appliance.

[0034] Furthermore, the present invention relates to a flame detector for an air-gas mixture burning appliance that comprises an air-gas mixing unit for mixing of air and gas, in particular hydrogen, to form a combustible air-gas mixture, and a burning unit with a burner surface that is arranged downstream of the air-gas mixing unit for burning the combustible air-gas mixture at the burner surface. The flame detector is adapted for sensing presence of a flame at the burner surface on the basis of a predetermined flame detection threshold that is adjustable to vary for at least two different operating points of the air-gas mixture burning appliance.

[0035] Thus, a new flame detector may be provided which allows an improved flame detection at the burner surface of the burning unit of the air-gas mixture burning appliance by means of an adjustment of the predetermined flame detection threshold for at least two different operating points of the air-gas mixture burning appliance.

More specifically, by adjusting the predetermined flame detection threshold for at least two different operating points, e.g. a detectable flame signal from a normal flame on the burner surface at a low firing rate of the air-gas mixing unit may reliably be recognised and distinguished from a detectable flame signal resulting from a sustained flashback at a high firing rate of the air-gas mixing unit. In this case, a conventionally predetermined flame detection threshold which is fixed and independent of any time-variant functional variables would either fail to detect the normal flame at the low firing rate, or fail to detect the sustained flashback at the high firing rate.

[0036] Moreover, the present invention relates to a method of operating an air-gas mixture burning appliance that comprises an air-gas mixing unit for mixing of air and gas, in particular hydrogen, to form a combustible air-gas mixture, a burning unit with a burner surface that is arranged downstream of the air-gas mixing unit for burning the combustible air-gas mixture at the burner surface, and a flame detector for sensing presence of a flame at the burner surface on the basis of a predetermined flame detection threshold. The method comprises adjusting the predetermined flame detection threshold for at least two different operating points of the air-gas mixture burning appliance.

[0037] Advantageously, the inventive method allows an improved flame detection at the burner surface of the burning unit of the air-gas mixture burning appliance by means of an adjustment of the predetermined flame detection threshold for at least two different operating points of the air-gas mixture burning appliance. More specifically, by adjusting the predetermined flame detection threshold for at least two different operating points, e.g. a detectable flame signal from a normal flame on the burner surface at a low firing rate of the air-gas mixing unit may reliably be recognised and distinguished from a detectable flame signal resulting from a sustained flashback at a high firing rate of the air-gas mixing unit. In this case, a conventionally predetermined flame detection threshold which is fixed and independent of any time-variant functional variables would either fail to detect the normal flame at the low firing rate, or fail to detect the sustained flashback at the high firing rate.

[0038] The predetermined flame detection threshold is preferably adjusted to avoid indication of a stable flame upon occurrence of a flame in the air-gas mixing unit under a sustained flashback event and/or in the event of a flame stabilising undesirably upstream of the burner surface.

[0039] Thus, overheating of the air-gas mixing unit and unwanted noise in case of a flashback may securely be avoided.

[0040] Preferably, adjusting the predetermined flame detection threshold comprises assigning a predetermined discrete threshold value to each one of the at least two different operating points.

[0041] Accordingly, the predetermined flame detection threshold may reliably be adjusted between the predetermined discrete threshold values. Advantageously, the predetermined discrete threshold values may be selected to enable reliably detection of a normal flame stabilised against the burner surface whilst failing to allow the detection of a flame, in particular at the air-gas mixing unit, under a sustained flashback event.

[0042] According to one aspect, adjusting the predetermined flame detection threshold comprises determining at least one of an operating state of the burning unit or at least one operating parameter of the air-gas mixture burning appliance, wherein at least one of the at least two different operating points corresponds to the at least one of an operating state of the burning unit or at least one operating parameter of the air-gas mixture burning appliance.

[0043] Thus, the predetermined flame detection threshold may advantageously be adjusted on the basis of a suitable time-variant operating state/parameter.

[0044] Preferably, a first operating state of the burning unit corresponds to an ignition phase of the burning unit, wherein a second operating state of the burning unit corresponds to a normal operating range of the burning unit.

[0045] Accordingly, a distinction between the ignition phase and the normal operating range of the burning unit may be made for a reliable and secure flame detection.

[0046] Preferably, adjusting the predetermined flame detection threshold further comprises associating a first predetermined flame detection threshold with the first operating state of the burning unit, and associating a second predetermined flame detection threshold with the second operating state of the burning unit, wherein the first predetermined flame detection threshold is smaller than the second predetermined flame detection threshold.

[0047] Thus, flame detection during the ignition phase and the normal operating range may easily be improved and adapted during operation of the burning unit.

[0048] According to one aspect, a first operating parameter of the air-gas mixture burning appliance corresponds to a first firing rate or a first range of firing rates of the air-gas mixing unit, or a first fan speed or a first range of fan speeds of a fan of the air-gas mixing unit, and a second operating parameter of the air-gas mixture burning appliance corresponds to a second firing rate or a second range of firing rates of the air-gas mixing unit, or a second fan speed or a second range of fan speeds of the fan.

[0049] Accordingly, a distinction between different firing rates or ranges of firing rates of the air-gas mixing unit, or between different fan speeds or ranges of fan speeds of the fan of the air-gas mixing unit may be made for a reliable and secure flame detection.

[0050] Preferably, adjusting the predetermined flame detection threshold further comprises associating a first predetermined flame detection threshold with the first operating parameter of the air-gas mixture burning appliance, and associating a second predetermined flame detection threshold with the second operating parameter of the air-gas mixture burning appliance, wherein the first

predetermined flame detection threshold is smaller than the second predetermined flame detection threshold.

[0051] Thus, flame detection may be made dependent on varying operating parameters and easily be improved and adapted during operation of the burning unit.

[0052] According to one aspect, the at least one operating parameter corresponds to at least one of a firing rate, a range of firing rates, a fan speed, a range of fan speeds, an air-gas ratio or a range of air-gas ratios.

[0053] Thus, various different operating parameters may be used for adjustment of the predetermined flame detection threshold.

[0054] Preferably, the predetermined flame detection threshold is associated with, and adjusted based on, the at least one operating parameter.

[0055] Accordingly, the predetermined flame detection threshold is not restricted to simply switching between two discrete flame detection thresholds, but will switch continuously depending on one of: the firing rate, range of firing rates, fan speed, range of fan speeds, air-gas ratio or range of air-gas ratios.

Brief Description of the Drawings

[0056] Exemplary embodiments of the present invention are described in detail hereinafter with reference to the attached drawings. In these attached drawings, identical or identically functioning components and elements are labelled with identical reference signs and they are generally only described once in the following description.

Fig. 1 shows a schematic view of an air-gas mixture burning appliance according to the present invention, at a low firing rate,

Fig. 2 shows a schematic view of the air-gas mixture burning appliance of Fig. 1, at a high firing rate,

Fig. 3 shows a schematic view of the air-gas mixture burning appliance of Fig. 2, for illustrating a sustained flashback event at the high firing rate,

Fig. 4 shows a perspective view of the air-gas mixture burning appliance of Fig. 3, for illustrating residual flames occurring during the sustained flashback event,

Fig. 5 shows a first functional diagram with different flame detection thresholds, for illustrating operation of the air-gas mixture burning appliance of Fig. 1 to Fig. 4,

Fig. 6 shows a second functional diagram with different flame detection thresholds, for illustrating operation of the air-gas mixture burning appliance of Fig. 1 to Fig. 4, and

Fig. 7 shows a third functional diagram with different flame detection thresholds, for illustrating operation of the air-gas mixture burning appliance of Fig. 1 to Fig. 4.

Detailed Description

[0057] Fig. 1 shows an exemplary air-gas mixture burning appliance 100 with an air-gas mixing unit 110, a burning unit 120, and a flame detector 150. By way of example, the air-gas mixture burning appliance 100 may be used in a boiler or, more generally, in a building heating system. Preferably, the gas used is hydrogen such that the air-gas mixture burning appliance 100 forms an air-hydrogen mixture burning appliance.

[0058] The air-gas mixing unit 110 is preferably adapted for mixing of air and gas to form a combustible air-gas mixture 130. Preferentially, the combustible air-gas mixture 130 is a homogenous mixture of the air and the gas.

[0059] By way of example, the air-gas mixing unit 110 includes an air supply 112 and a gas supply 116. Illustratively, the air supply 112 includes a fan 114 that may be operated with an adaptable fan speed and/or within predetermined ranges of fan speeds to draw air into the air-gas mixing unit 110.

[0060] The air supply 112 and the gas supply 116 may be interconnected via a predetermined number of mixers 118 which form a corresponding predetermined number of discrete points of mixing 119. Preferably, the combustible air-gas mixture 130 is formed at the predetermined number of discrete points of mixing 119 and guided via the predetermined number of mixers 118 to the burning unit 120.

[0061] Illustratively, the burning unit 120 is provided with a burner surface 124 that is arranged downstream of the air-gas mixing unit 110 such that the combustible air-gas mixture 130 that is formed at the predetermined number of discrete points of mixing 119 flows towards the burner surface 124. The combustible air-gas mixture 130 is burned by the burning unit 120 and, more specifically, at the burner surface 124.

[0062] By way of example, the burner surface 124 is illustrated with a comparatively small flame 122 which occurs e.g. at a low firing rate of the air-gas mixing unit 110, i.e. at a comparatively low rate at which feed of the combustible air-gas mixture 130 from the air-gas mixing unit 110 to the burning unit 120 occurs, in terms of volume, heat units, or weight per unit time. Such a low firing rate may e.g. be applied to the air-gas mixing unit 110 during an ignition phase of the air-gas mixture burning appliance 100. The comparatively small flame 122 is illustratively stabilised against the burner surface 124 and detected by means of the flame detector 150.

[0063] According to one aspect, the flame detector 150 is provided for sensing presence of the flame 122 at the burner surface 124 on the basis of a predetermined flame detection threshold. The predetermined flame detection threshold is preferably adjustable to vary for at least two

different operating points of the air-gas mixture burning appliance 100, as explained in detail at Fig. 5.

[0064] By way of example, the flame detector 150 detects a flame signal 160 that is directed toward the flame detector 150 and suitable for determining whether the flame 122 is present on the burner surface 124, or not. However, it should be noted that suitable flame detection techniques that may be used with the flame detector 150 are well-known to the person skilled in the art and are, therefore, not described in more detail, for brevity and conciseness. For instance, the flame detector 150 may use any suitable sensing element for sensing presence of the flame 122 at the burner surface 124.

[0065] Illustratively, the flame detector 150 is connected to a controller 140. Preferably, the controller 140 is adapted to control supply of gas to the air-gas mixing unit 110, in particular to the gas supply 116, on the basis of a detection signal 142 provided by the flame detector 150. The detection signal 142 may be created by the flame detector 150, or alternatively by the controller 140, by comparing the detected flame signal 160 to the predetermined flame detection threshold. Thus, the controller 140 may create a control signal 182 on the basis of the detection signal 142 which can be used e.g. to interrupt supply of gas to the air-gas mixing unit 110, in particular to the gas supply 116, if the detection signal 142 indicates an abnormal flame state at the burner surface 124. The controller 140 may be an integral part of the flame detector 150 or, as illustrated, a separate component of the air-gas mixture burning appliance 100.

[0066] Fig. 2 shows the air-gas mixture burning appliance 100 of Fig. 1 with the air-gas mixing unit 110, the burning unit 120, the controller 140, and the flame detector 150. However, in contrast to Fig. 1 the air-gas mixing unit 110 is now exemplarily operated at a high firing rate, which is e.g. associated with a normal operating range of the burning unit 120 compared to the low firing rate that is associated with the ignition phase of the air-gas mixture burning appliance 100, as described above at Fig 1.

[0067] The high firing rate leads, e.g. compared to the low firing rate, to a greater volume of the combustible air-gas mixture 130 that is available and burned at the burner surface 124 of the burning unit 120. Therefore, the flame 122 is now illustratively greater than in Fig. 1 and emits toward the flame detector 150 a flame signal 260 having a higher intensity than the flame signal 160 emitted by the flame 122 of Fig. 1.

[0068] Fig. 3 shows the air-gas mixture burning appliance 100 of Fig. 2 with the air-gas mixing unit 110, the burning unit 120, the controller 140, and the flame detector 150, wherein the air-gas mixing unit 110 is illustratively again operated at the high firing rate. However, in contrast to Fig. 2 the air-gas mixture burning appliance 100 is now shown in an undesirable operating scenario, wherein a flame 310 occurs in the air-gas mixing unit 110 under a sustained flashback event.

[0069] In other words, if a flashback occurs e.g. at the high firing rate in the normal operating range of the burning unit 120, the flame 310 may stabilise at the point of mixing 119 of the air-gas mixing unit 110. This, however, may lead to an unwanted overheating of the air-gas mixing unit 110, as well as to unwanted noise. According to one aspect, such an unwanted overheating of the air-gas mixing unit 110, as well as unwanted noise, may be avoided according to the present invention, as described below at Fig. 5.

[0070] More specifically, the flame 310 illustratively emits a flame signal 360, similar to the flame signal 260 emitted by the flame 122 of Fig. 2, which is directed toward the flame detector 150. If the flame signal 360 is detected by the flame detector 150 as a flame signal of a flame that is stabilised at the burner surface 124 of the burning unit 120, i.e. if a normal flame state is detected, the unwanted overheating of the air-gas mixing unit 110, as well as unwanted noise, may occur. Therefore, detection of the flame signal 360 by the flame detector 150 as a flame signal of a flame that is stabilised at the burner surface 124 of the burning unit 120 must be prevented and an abnormal flame state must instead be detected, as described below at Fig. 5.

[0071] Fig. 4 shows the air-gas mixture burning appliance 100 of Fig. 3 with the air-gas mixing unit 110, the burning unit 120, the controller 140, and the flame detector 150. However, in contrast to Fig. 3 the air-gas mixture burning appliance 100 is now shown in another undesirable operating scenario, wherein the flame 310 also occurs in the air-gas mixing unit 110 under a sustained flashback event.

[0072] Nevertheless, the flame 310 illustratively only occurs at a part of the predetermined number of mixers 118 of the air-gas mixing unit 110, while the combustible air-gas mixture 130 from the other mixers of the predetermined number of mixers 118 is burned at the burner surface 124 of the burning unit 120, thereby creating a flame 422, which illustratively corresponds to the small flame 122 of Fig. 1. This other undesirable operating scenario may occur at a given firing rate that is somewhere between the low firing rate of Fig. 1 and the high firing rate of Fig. 2.

[0073] The flame 422 illustratively emits a flame signal 460, similar to the flame signal 260 emitted by the flame 122 of Fig. 2, which is directed toward the flame detector 150. If the flame signal 460 is detected by the flame detector 150 as a flame signal of a flame that is stabilised at the burner surface 124 of the burning unit 120, i.e. if a normal flame state is detected, operation of the air-gas mixture burning appliance 100 is continued such that an unwanted overheating of the air-gas mixing unit 110, as well as unwanted noise, may occur. Therefore, detection of the flame signal 460 by the flame detector 150 as a flame signal of a flame that is stabilised at the burner surface 124 of the burning unit 120 must be prevented and an abnormal flame state must instead be detected, as described below at Fig. 5.

[0074] Fig. 5 shows a diagram 500 with an axis of ab-

scissae 510 that may e.g. represent different values of firing rates, fan speeds or air-gas ratios of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, as well as with an axis of ordinates 520 that illustrates intensities of different flame signals detected for the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4. More specifically, three different flame signal intensities 532, 534, and 536 are shown. By way of example, the flame signal intensity 532 is associated with the flame signal 160 of Fig. 1, the flame signal intensity 534 is associated with the flame signal 260 of Fig. 2, and the flame signal intensity 536 is associated with the flame signal 360 of Fig. 3 as well as the flame signal 460 of Fig. 4.

[0075] In order to avoid in the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 an unwanted overheating of the air-gas mixing unit 110, as well as unwanted noise, the flame signal intensity 536 must be recognised as being associated with an abnormal flame state at the burner surface 124 of the burning unit 120 of Fig. 1 to Fig. 4, while the flame signal intensities 532, 534 must be recognised as being associated with a normal flame state at the burner surface 124 of the burning unit 120 of Fig. 1 to Fig. 4. Thus, the controller 140 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 may control supply of gas to the air-gas mixing unit 110 correctly, as described above at Fig. 1.

[0076] As described above at Fig. 1, the flame detector 150 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 is provided for sensing presence of a flame at the burner surface 124 on the basis of a predetermined flame detection threshold. If the predetermined flame detection threshold is merely fixed and independent of any time-variant functional variables, the undesirable operating scenarios of Fig. 3 and Fig. 4 may occur, as described hereinafter with respect to two different fixed constant flame detection thresholds 562, 564. If, however, the predetermined flame detection threshold is adjustable, as described below with respect to an exemplary adjustable flame detection threshold 540, presence of the flame (310 in Fig. 3) in the air-gas mixing unit 110 under a sustained flashback event may be detected and suppressed. In other words, if the predetermined flame detection threshold 540 is adjustable, indication of a stable flame upon occurrence of a flame (310 in Fig. 3) in the air-gas mixing unit 110 under a sustained flashback event and/or in the event of a flame (310 in Fig. 3) stabilising undesirably upstream of the burner surface 124 may be avoided, as described in detail below.

[0077] By way of example, the fixed constant flame detection threshold 562 is selected such that the flame signal intensity 536 is below the fixed constant flame detection threshold 562 and may, thus, be recognised as being associated with an abnormal flame state. However, in this case the flame signal intensity 532 would also be recognised as being associated with an abnormal flame state, as it is also below the fixed constant flame detection threshold 562. Thus, a suitable functioning of the air-gas mixture burning appliance of Fig. 1 to Fig. 4 may not be guaranteed.

[0078] Furthermore, the fixed constant flame detection threshold 564 is illustratively selected such that the flame signal intensity 532 is above the fixed constant flame detection threshold 564 and may, thus, be recognised as being associated with a normal flame state. However, in this case the flame signal intensity 536 would also be recognised as being associated with a normal flame state, as it is also above the fixed constant flame detection threshold 564. Thus, a suitable functioning of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 may again not be guaranteed.

[0079] In contrast to the fixed constant flame detection thresholds 562, 564, the adjustable flame detection threshold 540 preferably comprises at least one predetermined discrete threshold value that is assigned to each one of at least two different operating points. At least one of the at least two different operating points may correspond to an operating state of the burning unit 120 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, or at least one operating parameter of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4.

[0080] By way of example, the first operating state of the burning unit 120 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 corresponds to an ignition phase 572 of the burning unit 120, as illustrated in Fig. 1, and a second operating state of the burning unit 120 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 corresponds to a normal operating range or operating phase 574 of the burning unit 120, as illustrated in Fig. 2. Duration of the ignition phase 572 and the normal operating phase 574 are exemplarily illustrated on an associated time-axis 570.

[0081] Accordingly, a first predetermined flame detection threshold 542 is associated by way of example with the first operating state, and a second predetermined flame detection threshold 544 is associated with the second operating state, the first predetermined flame detection threshold 542 being smaller than the second predetermined flame detection threshold 544. Illustratively, the first predetermined flame detection threshold 542 corresponds to the fixed constant flame detection threshold 564, and the second predetermined flame detection threshold 544 corresponds to the fixed constant flame detection threshold 562. The transition between the first and second predetermined flame detection thresholds 542, 544 may be abrupt, as illustrated, or alternatively be implemented as a ramp (630 in Fig. 6) with one or more different slopes, as described below at Fig. 6.

[0082] Illustratively, the first and second predetermined flame detection thresholds 542, 544 are selected such that all flame signal entities above the first and second predetermined flame detection thresholds 542, 544 are falling into a region 552 that is associated with a normal flame state. Similarly, the first and second predetermined flame detection thresholds 542, 544 are selected such that all flame signal intensities below the first and second predetermined flame detection thresholds 542,

544 are falling into a region 554 that is illustratively hatched and associated with an abnormal flame state.

[0083] More specifically, the first predetermined flame detection threshold 542 is illustratively selected such that the flame signal intensity 532 is above the first predetermined flame detection threshold 542 and may, thus, be recognised as being associated with a normal flame state. The second predetermined flame detection threshold 544 is illustratively selected such that the flame signal intensity 534 is above the second predetermined flame detection threshold 544 and may, thus, be recognised as being associated with a normal flame state, while the flame signal intensity 536 is below the second predetermined flame detection threshold 544 and may, thus, be recognised as being associated with an abnormal flame state. Accordingly, a suitable functioning of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 may be guaranteed.

[0084] It should be noted that the example described above only relates to possible operating states of the burning unit 120 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4. However, as described above the at least two different operating points may not only correspond to the operating states of the burning unit 120 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, but also, or alternatively, to operating parameters of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4. By way of example, a first operating parameter of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 may correspond to a first firing rate or a first range of firing rates of the air-gas mixing unit 110 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, or a first fan speed or a first range of fan speeds of the fan 114 of the air-gas mixing unit 110, and a second operating parameter of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 may correspond to a second firing rate or a second range of firing rates of the air-gas mixing unit 110 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, or a second fan speed or a second range of fan speeds of the fan 114 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4. In this case, the first predetermined flame detection threshold 542 may be associated with the first operating parameter of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, and the second predetermined flame detection threshold 544 may be associated with the second operating parameter of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, the first predetermined flame detection threshold 542 being smaller than the second predetermined flame detection threshold 544.

[0085] It should be noted that the firing rates or ranges of firing rates of the air-gas mixing unit 110 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, as well as the fan speeds or ranges of fan speeds of the fan 114 of the air-gas mixing unit 110 are only cited by way of example, and not for limiting the invention accordingly. Instead, other operating parameters are likewise contemplated, such as e.g. air-gas ratios or ranges of air-gas ratios of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4.

[0086] In an exemplary operation of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, the predetermined flame detection threshold 540 is preferably adjusted at least for the two different operating points described above. For instance, if the first operating point is associated with an ignition phase 572 and the second operating point is associated with a normal operating range 574 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, then the predetermined flame detection threshold 540 may be adjusted from the first predetermined flame detection threshold 542 to the second predetermined flame detection threshold 544 upon transition from the ignition phase 572 to the normal operating range 574.

[0087] Fig. 6 shows a diagram 600 with an axis of abscissae 610 that may e.g. represent different values of firing rates, fan speeds or air-gas ratios of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, as well as with an axis of ordinates 620 that illustrates intensities of different flame signals detected for the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4. Illustratively, the three different flame signal intensities 532, 534, and 536 of Fig. 5 are shown, as well as the adjustable flame detection threshold 540 with the first predetermined flame detection threshold 542 and the second predetermined flame detection threshold 544 of Fig. 5.

[0088] More generally, the diagram 600 essentially corresponds to the diagram 500 of Fig. 5 and the time-axis 570 of Fig. 5 is also shown. However, in contrast to the diagram 500, the transition of the adjustable flame detection threshold 540 between the first and second predetermined flame detection thresholds 542, 544 is now no more abrupt, but implemented as a ramp 630.

[0089] Fig. 7 shows a diagram 700 with an axis of abscissae 710 that may e.g. represent different values of firing rates, fan speeds or air-gas ratios of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4, as well as with an axis of ordinates 720 that illustrates intensities of different flame signals detected for the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4. Illustratively, the three different flame signal intensities 532, 534, and 536 of Fig. 6 are shown, as well as the adjustable flame detection threshold 540 with the first predetermined flame detection threshold 542, the second predetermined flame detection threshold 544, and the ramp 630 of Fig. 6.

[0090] More generally, the diagram 700 essentially corresponds to the diagram 600 of Fig. 6, and the time-axis 570 of Fig. 6 is also shown. However, in contrast to the diagram 600, the diagram 700 further comprises two additional flame signal intensities 732, 734, which are exemplarily occurring in the normal operating range 574. For instance, the flame signal intensity 732 relates to an abnormal flame state and results e.g. from an increase of the firing rate of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 starting at the firing rate underlying the flame signal intensity 536. In contrast, the flame signal

intensity 734 exemplarily relates to a normal flame state. Accordingly, in order to guarantee a correct detection of the abnormal flame state associated with the flame signal intensity 732 and the normal flame state associated with the flame signal intensity 734, the adjustable flame detection threshold 540 is adjusted from the second predetermined flame detection threshold 544 to a third predetermined flame detection threshold 546, which illustratively corresponds to a fixed constant flame detection threshold 762, by means of a transition 730 in form of a ramp.

[0091] By way of example, the firing rate is decreased after detection of the flame signal intensities 732, 734. Therefore, the adjustable flame detection threshold 540 is re-adjusted from the third predetermined flame detection threshold 546 back to the second predetermined flame detection threshold 544 by means of another transition 740 in form of another ramp.

[0092] In other words, it becomes clear from Fig. 5 to Fig. 7 that the adjustable flame detection threshold 540 may preferably generally be adjusted between two or more different predetermined flame detection thresholds. Each adjustment may be performed in an abrupt, sudden step action or gradually, e.g. by means of a ramp having one or more different slopes. Furthermore, an adjustment of the adjustable flame detection threshold 540 may occur at any moment, i.e. not only between the ignition phase 572 and the normal operating range 574, but e.g. also during the normal operating range 574. For instance, if a firing rate of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 4 increases or decreases during the normal operating range 574, then the adjustable flame detection threshold 540 is preferably likewise increased or decreased to match a respective increase or decrease of the firing rate.

Claims

1. An air-gas mixture burning appliance (100), comprising:

   an air-gas mixing unit (110) for mixing of air and gas to form a combustible air-gas mixture (130), a burning unit (120) with a burner surface (124) that is arranged downstream of the air-gas mixing unit (110) for burning the combustible air-gas mixture (130) at the burner surface (124), and
   a flame detector (150) for sensing presence of a flame (122) at the burner surface (124) on the basis of a predetermined flame detection threshold (540) that is adjustable to vary for at least two different operating points of the air-gas mixture burning appliance (100).

2. The air-gas mixture burning appliance of claim 1, wherein the predetermined flame detection threshold (540) is adjustable to avoid indication of a stable flame upon occurrence of a flame (310) in the air-gas mixing unit (110) under a sustained flashback event and/or in the event of a flame (310) stabilising undesirably upstream of the burner surface (124).

3. The air-gas mixture burning appliance of claim 1 or 2, wherein a predetermined discrete threshold value is assigned to each one of the at least two different operating points.

4. The air-gas mixture burning appliance of any one of the preceding claims, wherein at least one of the at least two different operating points corresponds to an operating state of the burning unit (120) or at least one operating parameter of the air-gas mixture burning appliance (100).

5. The air-gas mixture burning appliance of claim 4, wherein a first operating state of the burning unit (120) corresponds to an ignition phase of the burning unit (120), and wherein a second operating state of the burning unit (120) corresponds to a normal operating range of the burning unit (120).

6. The air-gas mixture burning appliance of claim 5, wherein a first predetermined flame detection threshold (542) is associated with the first operating state of the burning unit (120), wherein a second predetermined flame detection threshold (544) is associated with the second operating state of the burning unit (120), and wherein the first predetermined flame detection threshold (542) is smaller than the second predetermined flame detection threshold (544).

7. The air-gas mixture burning appliance of claim 4, wherein a first operating parameter of the air-gas mixture burning appliance (100) corresponds to a first firing rate or a first range of firing rates of the air-gas mixing unit (110), or a first fan speed of a fan (114) of the air-gas mixing unit (110), and wherein a second operating parameter of the air-gas mixture burning appliance (100) corresponds to a second firing rate or a second range of firing rates of the air-gas mixing unit (110), or a second fan speed of the fan (114).

8. The air-gas mixture burning appliance of claim 7, wherein a first predetermined flame detection threshold (542) is associated with the first operating parameter of the air-gas mixture burning appliance (100), wherein a second predetermined flame detection threshold (544) is associated with the second operating parameter of the air-gas mixture burning appliance (100), and wherein the first predetermined flame detection threshold (542) is smaller than the second predetermined flame detection threshold

(544).

9. The air-gas mixture burning appliance of claim 4, wherein the at least one operating parameter corresponds to at least one of a firing rate, a range of firing rates, a fan speed, a range of fan speeds, an air-gas ratio or a range of air-gas ratios.

10. The air-gas mixture burning appliance of claim 9, wherein the predetermined flame detection threshold (540) is associated with, and adjusted based on, the at least one operating parameter.

11. The air-gas mixture burning appliance of any one of the preceding claims, further comprising a controller (140) that is connected to the flame detector (150) and adapted to control supply of gas to the air-gas mixing unit (110) on the basis of a detection signal (142) provided by the flame detector (150).

12. The air-gas mixture burning appliance of claim 11, wherein the controller (140) is adapted to interrupt supply of gas to the air-gas mixing unit (110) if the detection signal (142) indicates an abnormal flame state at the burner surface (124).

13. The air-gas mixture burning appliance of any one of the preceding claims, wherein the gas is hydrogen.

14. A flame detector (150) for an air-gas mixture burning appliance (100) that comprises an air-gas mixing unit (110) for mixing of air and gas, in particular hydrogen, to form a combustible air-gas mixture (130), and a burning unit (120) with a burner surface (124) that is arranged downstream of the air-gas mixing unit (110) for burning the combustible air-gas mixture (130) at the burner surface (124), the flame detector (150) being adapted for sensing presence of a flame (122) at the burner surface (124) on the basis of a predetermined flame detection threshold (540) that is adjustable to vary for at least two different operating points of the air-gas mixture burning appliance (100).

15. A method of operating an air-gas mixture burning appliance (100) that comprises an air-gas mixing unit (110) for mixing of air and gas, in particular hydrogen, to form a combustible air-gas mixture (130), a burning unit (120) with a burner surface (124) that is arranged downstream of the air-gas mixing unit (110) for burning the combustible air-gas mixture (130) at the burner surface (124), and a flame detector (150) for sensing presence of a flame (122) at the burner surface (124) on the basis of a predetermined flame detection threshold (540), the method comprising:
Adjusting the predetermined flame detection threshold (540) for at least two different operating points of the air-gas mixture burning appliance (100).

16. The method of claim 15, wherein the predetermined flame detection threshold (540) is adjustable to avoid indication of a stable flame upon occurrence of a flame (310) in the air-gas mixing unit (110) under a sustained flashback event and/or in the event of a flame (310) stabilising undesirably upstream of the burner surface (124).

17. The method of claim 15 or 16, wherein adjusting the predetermined flame detection threshold (540) comprises assigning a predetermined discrete threshold value to each one of the at least two different operating points.

18. The method of any one of claims 15 to 17, wherein adjusting the predetermined flame detection threshold (540) comprises determining at least one of an operating state of the burning unit (120) or at least one operating parameter of the air-gas mixture burning appliance (100), wherein at least one of the at least two different operating points corresponds to the at least one of an operating state of the burning unit (120) or at least one operating parameter of the air-gas mixture burning appliance (100).

19. The method of claim 18, wherein a first operating state of the burning unit (120) corresponds to an ignition phase of the burning unit (120), and wherein a second operating state of the burning unit (120) corresponds to a normal operating range of the burning unit (120).

20. The method of claim 19, wherein adjusting the predetermined flame detection threshold (540) further comprises associating a first predetermined flame detection threshold (542) with the first operating state of the burning unit (120), and associating a second predetermined flame detection threshold (544) with the second operating state of the burning unit (120), wherein the first predetermined flame detection threshold (542) is smaller than the second predetermined flame detection threshold (544).

21. The method of claim 18, wherein a first operating parameter of the air-gas mixture burning appliance (100) corresponds to a first firing rate or a first range of firing rates of the air-gas mixing unit (110), or a first fan speed of a fan (114) of the air-gas mixing unit (110), and wherein a second operating parameter of the air-gas mixture burning appliance (100) corresponds to a second firing rate or a second range of firing rates of the air-gas mixing unit (110), or a second fan speed of the fan (114).

22. The method of claim 21, wherein adjusting the predetermined flame detection threshold (540) further comprises associating a first predetermined flame detection threshold (542) with the first operating pa-

rameter of the air-gas mixture burning appliance (100), and associating a second predetermined flame detection threshold (544) with the second operating parameter of the air-gas mixture burning appliance (100), wherein the first predetermined flame detection threshold (542) is smaller than the second predetermined flame detection threshold (544).

23. The method of claim 18, wherein the at least one operating parameter corresponds to at least one of a firing rate, a range of firing rates, a fan speed, a range of fan speeds, an air-gas ratio or a range of air-gas ratios.

24. The method of claim 23, wherein the predetermined flame detection threshold (540) is associated with, and adjusted based on, the at least one operating parameter.

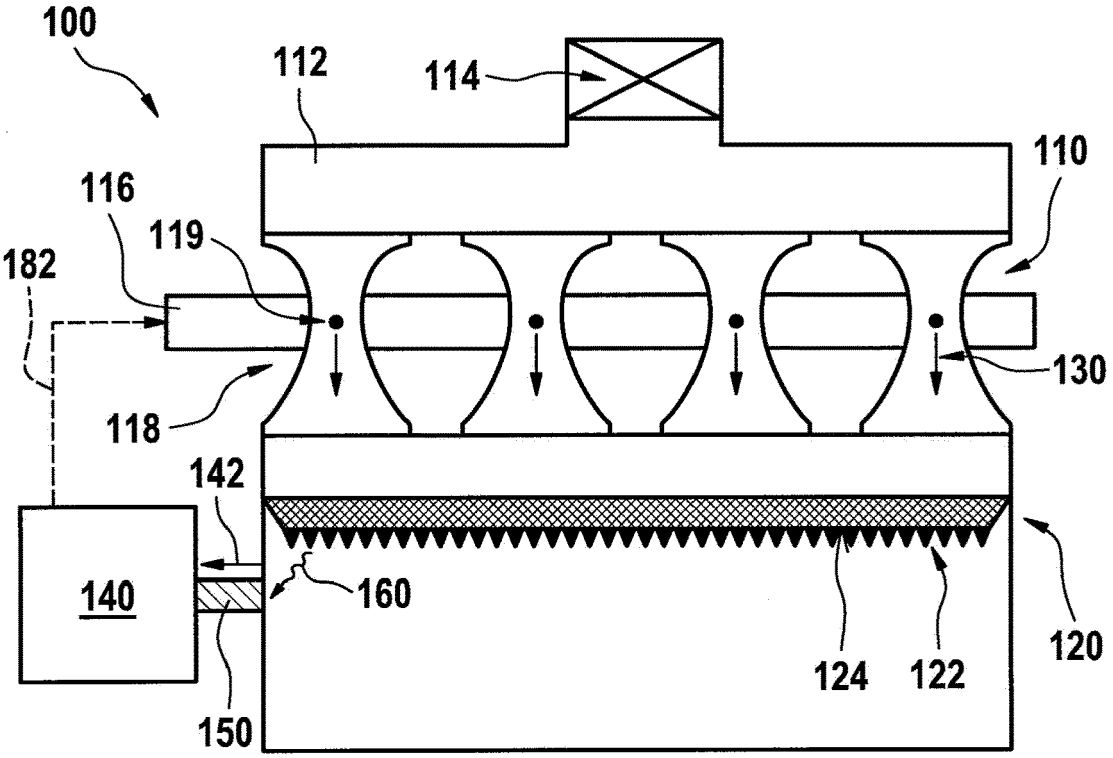
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FIG. 1

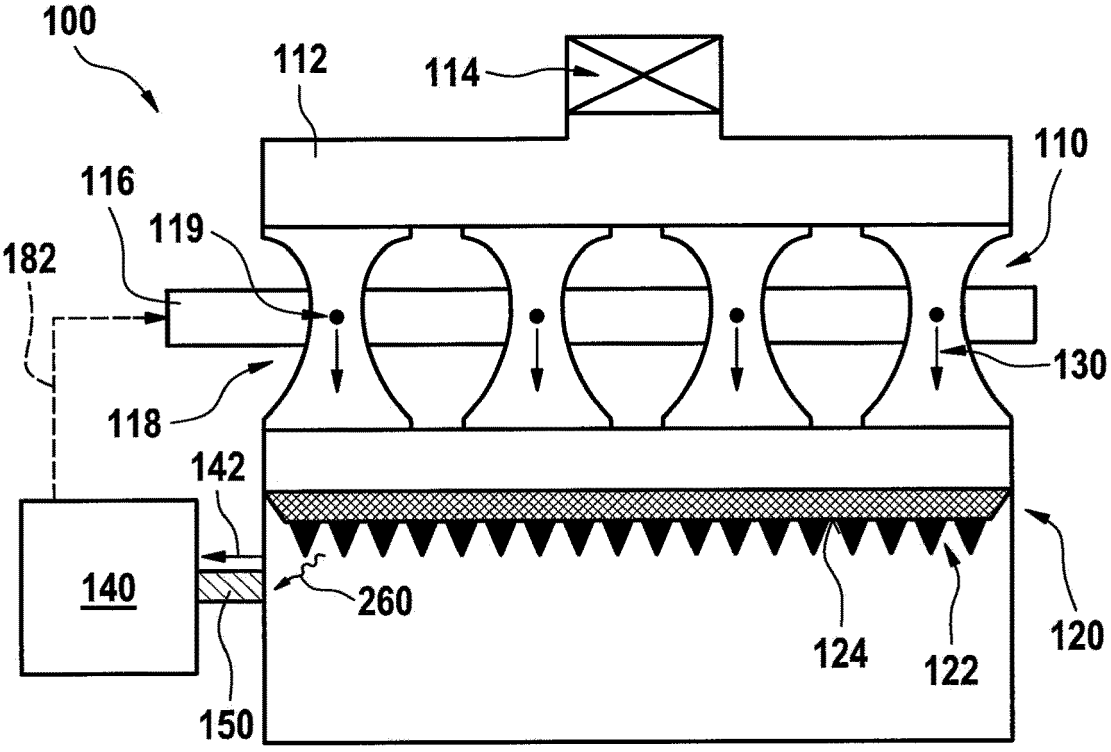
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FIG. 2

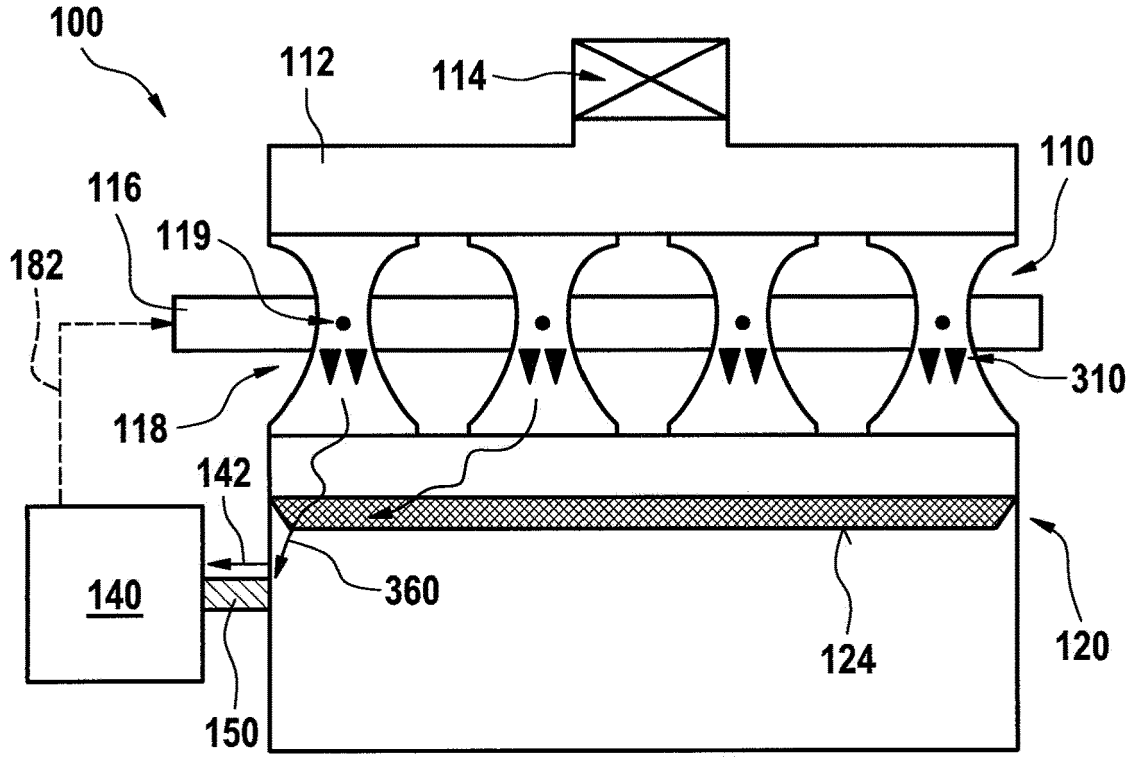
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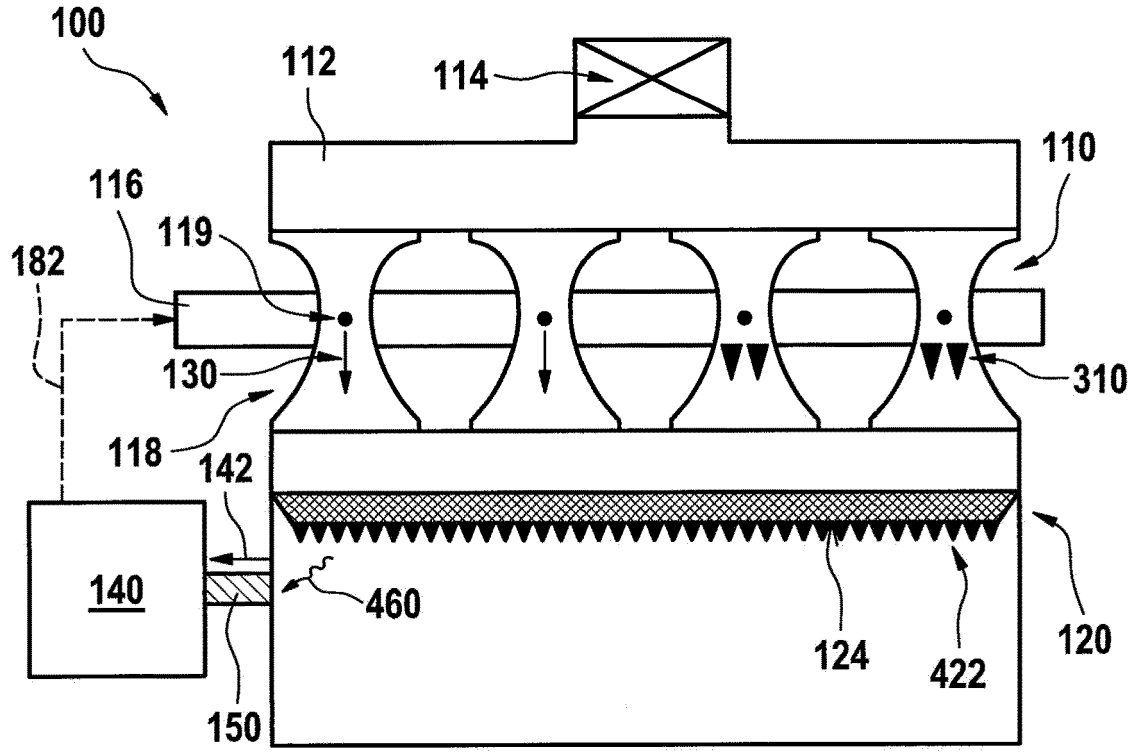
FIG. 3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150

FIG. 4

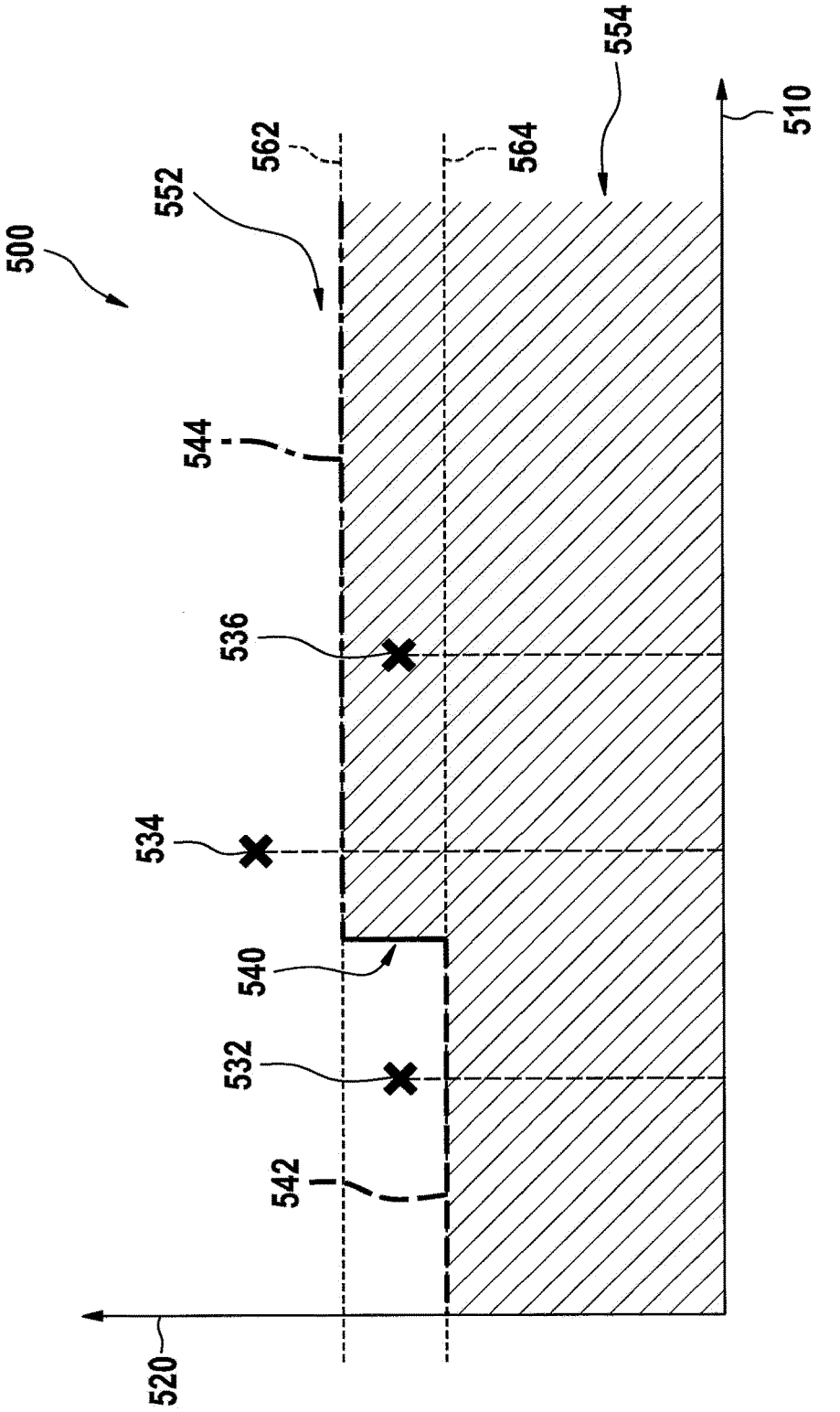
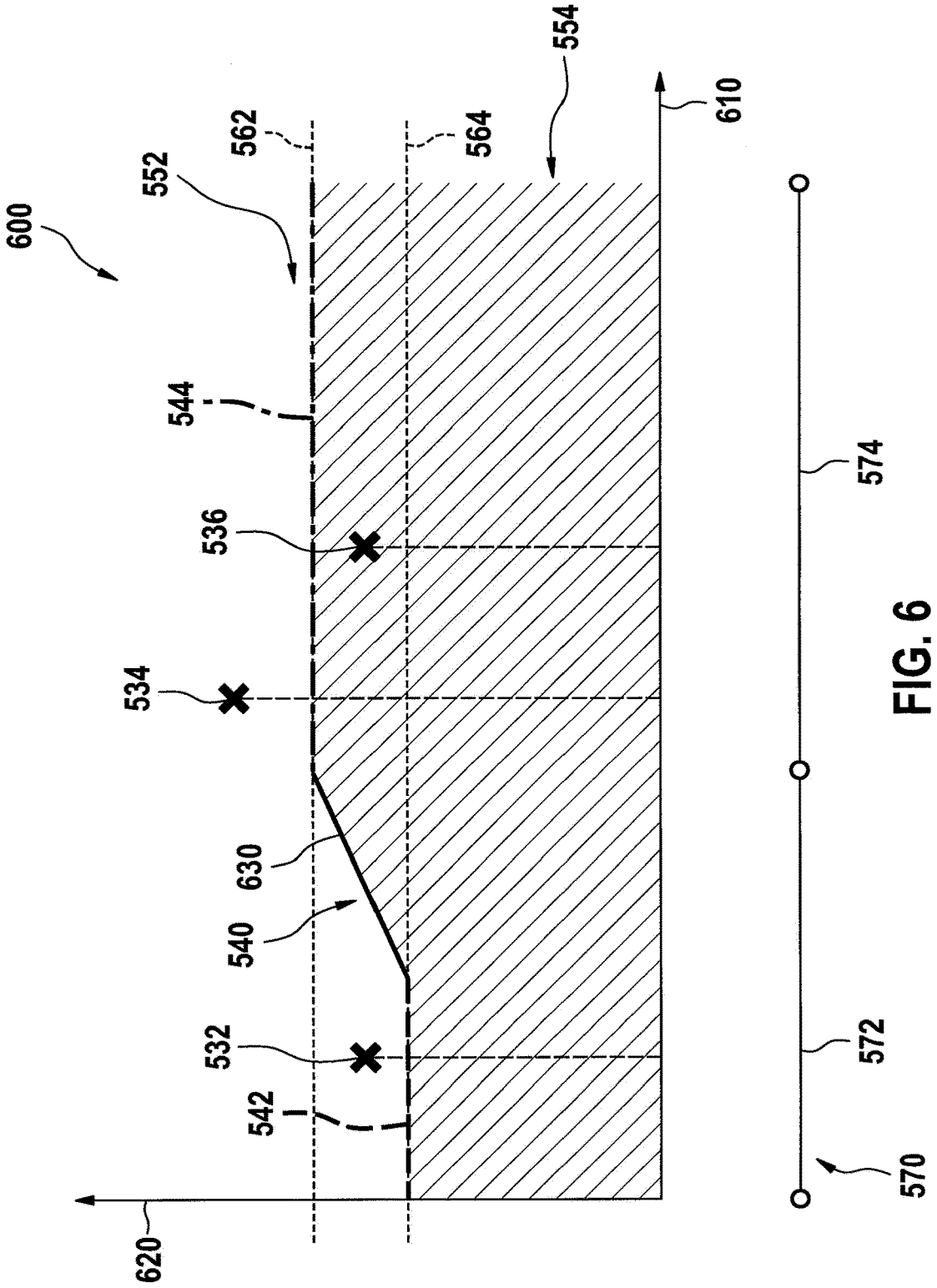


FIG. 5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610
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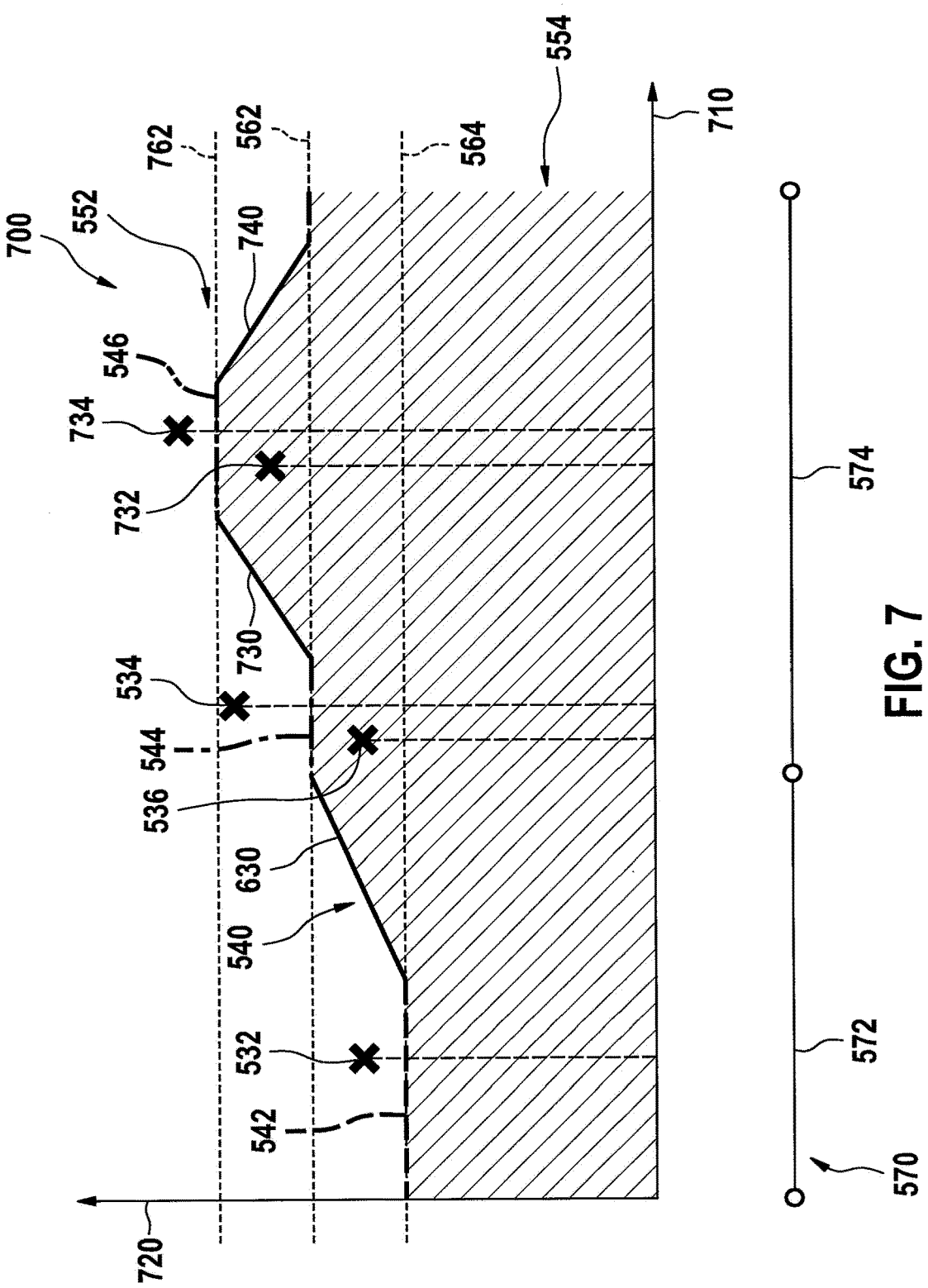
FIG. 6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572
570

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 21 19 1586

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2019/338956 A1 (HUANG CHUNG-CHIN [TW] ET AL) 7 November 2019 (2019-11-07)	1,3-12, 14,15, 17-24	INV. F23D14/02 F23D14/72
Y	* paragraph [0001]; figures 3-5 * * paragraph [0009] - paragraph [0013] * * paragraph [0022] - paragraph [0032] * * paragraph [0036] *	13	F23N5/24
A	GB 2 185 609 A (WILLEY ROBINSON LTD) 22 July 1987 (1987-07-22) * page 1, line 5 - line 14; figure 1 * * page 1, line 30 - line 102 *	2,16	
Y	US 6 162 049 A (PELLIZZARI ROBERTO O [US] ET AL) 19 December 2000 (2000-12-19)	13	
A	* column 1, line 5 - line 8; figures 1,2 * * column 1, line 41 - line 50 * * column 1, line 60 - line 65 * * column 2, line 28 - line 62 * * column 4, line 27 - line 39 *	14,15	

TECHNICAL FIELDS SEARCHED (IPC)
F23D
F23C
F23N

1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 January 2022	Hauck, Gunther

CATEGORY OF CITED DOCUMENTS

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19-01-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019338956 A1	07-11-2019	NONE	
GB 2185609 A	22-07-1987	NONE	
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82