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(54)

GAS MIXING MANIFOLD

(57) Manifold (1) for a combustion appliance (2), in particular for a gas boiler, for distributing an air/gas mixture to a burner (3) of said combustion appliance (2), the manifold (1) having a one-piece hollow frame structure (4) comprising a first inlet section (6) for receiving fuel gas through a first inlet opening (5), a second inlet section (7) for receiving air through a second inlet opening (10), the second inlet section (7) being located upstream the first inlet section (6), and an outlet section (8) for releasing the air/gas mixture to the burner (3) through an outlet opening (9), the outlet section (7) being located down-stream the first inlet section (6) and the second inlet section (7), wherein the manifold (1) comprises a mixer (11) for allowing the mixing of the fuel gas and air at a mixer outlet (12).

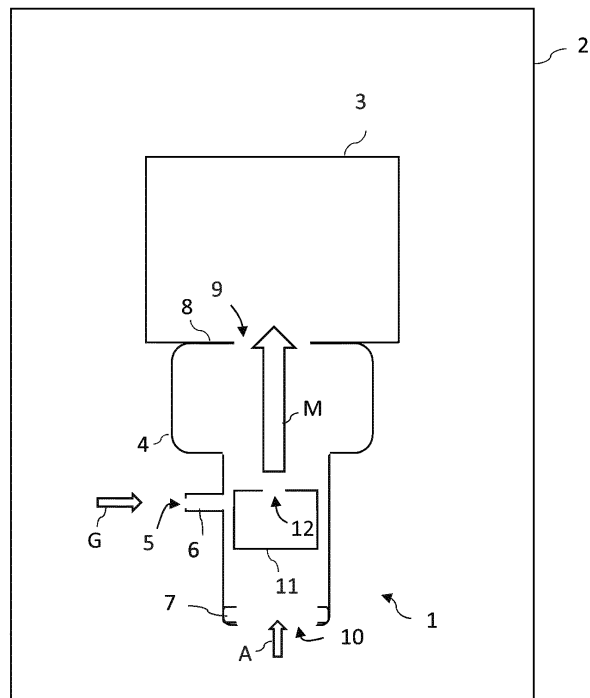


FIG. 1

Description

[0001] The invention relates to a manifold for a combustion appliance. Additionally, the invention relates to a combustion appliance comprising said manifold and the use of the manifold in a combustion appliance for the combustion of fuel gas, in particular comprising at least 20 mol% hydrogen, in particular pure hydrogen, natural gas or mixtures thereof.

[0002] Nowadays, the majority of boilers are gas boilers and are designed for natural gas, using hydrocarbons as fuel gas. Gas boilers combust gas fuel to heat water for domestic use and/or central heating systems in buildings. The market is looking into cleaner alternatives for combusting natural gas. One of these alternatives is combusting fuel gas comprising 20 mol% hydrogen, in particular pure hydrogen, or natural gas or mixtures thereof. It is noted that gas boilers combusting pure hydrogen (i.e. hydrogen boiler) are boilers to which fuel gas is supplied that comprises at least 90 mol% hydrogen. Currently, there are natural gas (or propane) boilers on the market which are only suitable to combust up to 20% hydrogen into the gas blend (according to the specifications). In other words, current boilers on the market are not directly suitable for combustion of hydrogen and important modifications are needed to possibly convert a standard natural gas boiler into a hydrogen boiler. These modifications are in most cases expensive and time consuming.

[0003] For example, when using natural gas as fuel gas in a gas boiler, the mixing between fuel gas and air usually occurs in the blower (i.e. fan element). However, when using different types of gas fuels, such as hydrogen, due to the high flammability range and the low energy ignition of this gas, a system where the gas/air mixing happens in the blower could be very dangerous for some friction (defected blower, risk of spark) of the mechanical part of the fan that could trigger an unexpected ignition. For this reason, in gas boilers using hydrogen as fuel gas, it is better to mix the fuel gas and air after the blower (PAS 4444:2020, Hydrogen-fired gas appliances. Guide section 5.3.6). The air from the blower is pushed in a conduit while the gas from the gas valve is pushed in a different part of the conduit passing through a sort of mixer.

[0004] In addition, when using hydrogen as fuel gas, other issues should be taken into account, such as the flashback. Accordingly, dedicated flashback suppressors need to be inserted in the boiler at the port of the burner in order to manage this phenomenon.

[0005] Existent solutions try to cope with these issues by simply adding specific components, such as a Venturi mixer and/or a flashback suppressor to already known configurations suitable, for example, for other types of gas boilers. In other words, a mixer and/or a flashback suppressor can be added to the conduit (i.e. the manifold) connecting the blower to the burner of the boiler. However, if this can be efficient from a functional point of view,

the size of the connection system increases, thereby increasing also the risk of malfunctioning.

[0006] It is therefore desirable to obtain an efficient, safe, and relatively low-cost connection system suitable to be used in hydrogen gas boilers for transporting an air/gas mixture to the burner by reducing to the minimum the size and the number of structural components to be used in the connecting system.

[0007] The object of the invention is therefore to provide a manifold that is cost-effective, safe, and that is effective in coping with risks in connection with distributing an air/gas mixture to the burner of a boiler configured to combust hydrogen.

[0008] The object is solved by a manifold for a combustion appliance, in particular for a gas boiler, for distributing an air/gas mixture to a burner of said combustion appliance, the manifold having a one-piece hollow frame structure comprising a first inlet section for receiving fuel gas through a first inlet opening, a second inlet section for receiving air through a second inlet opening, the second inlet section being located upstream the first inlet section, and an outlet section for releasing the air/gas mixture to the burner through an outlet opening, the outlet section being located downstream the first inlet section and the second inlet section, wherein the manifold comprises a mixer for allowing the mixing of the fuel gas and air at a mixer outlet.

[0009] In this way, the mixer is located downstream the connection for receiving air, i.e. after the blower, thereby reducing the air/gas mixture and consequently reducing an unexpected ignition in case of flashback. Also, the mixer is merged directly in the manifold frame structure since it is inserted in the frame structure of the manifold passing through the second inlet opening. Therefore, the connection system transporting air/gas mixture to the burner is more compact and less structural components as possible are used that is a safety feature for hydrogen gas boiler. This means less mechanical connections and possible gas leakages as well as easy maintenance and accessibility for the service people.

[0010] In one example, the mixer can be inserted into the frame structure through the second inlet opening. Alternatively, the mixer can be inserted into the frame structure through a different opening, for example through the outlet opening or the first inlet opening. Additionally, the mixer can comprise a main body having a first region for receiving fuel gas from the first inlet section and extending transversally in the main body, and a second region for receiving air from the second inlet section and extending longitudinally in the main body. The mixer is structurally compact and the main body comprises two regions dedicated to receive the fuel gas and the air arranged in such a way to efficiently provide an air/gas mixture at the mixer outlet.

[0011] In particular, the mixer can comprise an elongated hollow structure located in the first region, said elongated structure comprising a gas inlet coupled to the first inlet section and an outlet slot for releasing the fuel

gas at the mixer outlet. The gas flows outside from the slot and it is pulled by the air (pushed by the fan from the bottom). Since the gas, in particular hydrogen, is lighter than the air, it tends to rise. It is noted that the effect of pulling the gas by the air helps the mixing.

[0012] The elongated structure can have a suitable shape. For example, the elongated structure can have a funnel shape. This can advantageously provide a homogeneous distribution of the gas at the mixer outlet. In a particular configuration, in order to better facilitate the mixing between the fuel gas and the air at the mixer outlet, the outlet slot of the elongated structure at the gas inlet can have an increased aperture, in particular in comparison to the remaining part of the outlet slot.

[0013] In another example, the mixer outlet can have a polygonal cross section, in particular a rectangular cross-section. Also, the main body of the mixer can have a polygonal cross section, in particular a rectangular cross-section. In addition, the second inlet opening can have a polygonal shape, in particular a rectangular shape. It is noted that the particular shape of the mixer outlet improves the mixing of the gas with the air. Also, this shape as well as the shape of the main body of the mixer can be adapted to the shape of the manifold, i.e. of the shape of the second inlet opening, in order to facilitate the insertion of the mixer in the frame structure of the manifold and increasing the overall compactness of the system. As mentioned above, alternatively, the mixer can be inserted into the frame structure through a different opening, for example through the outlet opening or the first inlet opening.

[0014] In a further example, the mixer comprises one or more engaging means, in particular pins or fins, and the second inlet section comprises one or more guiding means, in particular seats or slots, for allowing the positioning and guiding of the mixer inside the manifold. In this way, the mixer can be easily inserted and fixed inside the manifold.

[0015] In another example, at the mixer outlet a cross-sectional gas flow area and a cross-sectional air flow area are present, wherein the cross-sectional gas flow area at the mixer outlet is smaller than the cross-sectional air flow area. Additionally or alternatively, the ratio between the cross-sectional gas flow area and the cross-sectional air flow area at the mixer outlet is comprised between 0.13 and 0.17.

[0016] As mentioned above, the mixer is designed with a specific shape in order to have the optimal mixing between gas and the air from the blower. The aim is to have the mixing just before the burner and not inside the burner. In fact, if the mixing occurs in the burner, the flame distribution could be not uniform. This could create different temperature area on the burner deck with consequent not expected combustion values. The position in the manifold is in according with pressure loss and the minimum opening area is defined by the crossing section of the manifold. For example, the cross sectional gas area can depend on the power of the burner has to pro-

vide. In particular, the cross sectional gas area can be advantageously less than 1/3 of the crossing section of the manifold. More particularly, in order to decrease the pressure loss, the ratio between the cross-sectional gas flow area and the cross-sectional air flow area at the mixer outlet can be between 1:6 to 1:7. With these values, a correct compromise between free air area and gas area is obtained. In this way, less pressure loss as possible is ensured in order to have a reasonable fan speed at maximum heat input and enough gas to reach the maximum heat input. It is noted that these values can vary based on the manifold dimension. However, they are particularly advantageous for combustion appliance, such as gas boilers of up to 28kW.

[0017] In one example, the manifold further comprises a suppressor located in the frame structure downstream the mixer for avoiding a flame back in the manifold. The no return valve in standard boilers (e.g. natural gas boilers) is used to avoid flue recirculation in case of multiple boiler installation. In hydrogen application, this valve blocks the flame back in the manifold/blower in case of flashback also reducing the noise of the explosion. It is noted that the suppressor has a specific shape and weight to have a compromise in terms of pressure lost in the system, response of the flashback, and anti-rebound phenomena.

[0018] Also, the manifold further comprises a mixing chamber positioned downstream the mixer, in particular between the mixer outlet and the outlet opening of the outlet portion, for mixing the fuel gas and the air received from the mixer.

[0019] In particular, the manifold further comprises a first seat for positioning the suppressor, the first seat being located in the mixing chamber. In other words, the suppressor is merged in the frame structure of the manifold and the manifold is specifically designed to contain a flashback suppressor by providing a dedicated seat. In this way, it is possible to use a single integrated part that is a multipurpose element constituted by a manifold to drive the air/gas mixture to the burner, with a mixer to adequately mix fuel gas and air after the fan element and a suppressor to suppress any possible flashback.

[0020] According to an example, the second inlet section of the manifold is connectable to a fan element. In this way, the present manifold can simply be connected between the fan element and the burner so that the mixing of the air and fuel gas can occur after the blower/fan element, thereby reducing the risk on an expected ignition when using hydrogen as fuel gas.

[0021] In order to monitor a, in particular mass, flow rate, the manifold can further comprise a second seat for a, in particular mass, flow sensor, the second seat being located at the first inlet section downstream the first inlet opening. Additionally or alternatively, the manifold can further comprise a third seat for a, in particular mass, flow sensor, the third seat can be located at the second inlet section.

[0022] The manifold can further comprise a gas regu-

lation valve to limit the maximum gas flow in the manifold. This valve acts as a sort of restrictor to limit the maximum gas flow in case of malfunction of the gas valve. This part can prevent unexpected no safety situation.

[0023] According to one aspect of the invention, a combustion appliance, in particular a gas boiler, is provided, the combustion appliance comprising an inventive manifold. Examples of combustion appliances can include furnaces, water heaters, boilers, direct/in-direct make-up air heaters, power/jet burners and any other residential, commercial or industrial combustion appliance.

[0024] In particular, the appliance including the present manifold can be a gas boiler for the combustion of pure hydrogen gas. In this case, it is intended a fuel gas that comprises at least 90 mol% hydrogen.

[0025] In another aspect of the invention, the use of the inventive manifold in a combustion appliance for the combustion of fuel gas, in particular comprising at least 20 mol% hydrogen, in particular pure hydrogen, natural gas or mixtures thereof. By using the present manifold in a hydrogen gas boiler, it is possible to respect all the safety issues when managing H₂ as fuel gas using a compact and cost effective multipurpose manifold.

[0026] In the figures, the subject-matter of the invention is schematically shown, wherein identical or similarly acting elements are usually provided with the same reference signs.

Figure 1 shows a schematic representation of a manifold connected to the burner of a combustion appliance according to an example.

Figures 2A-B show a schematic representation of a frame structure of the manifold according to an example.

Figures 3A-B show a schematic representation of a frame structure of the manifold with a suppressor according to an example.

Figures 4A-B show a schematic representation of the mixer according to an example.

Figures 5A-B show a schematic representation of the mixer according to another example.

[0027] With reference to Figure 1, a manifold 1 is shown. The manifold 1 is connected to a burner 3 of a gas appliance 2 (e.g. a gas boiler, in particular a hydrogen boiler). The manifold 1 receives air A and fuel gas G and provides the burner 3 with an air/gas mixture M. The manifold 1 has a frame structure 4, in particular a hollow one-piece frame structure made of metal, for example aluminum, realized with tooling machines. The frame 4 comprises a first inlet section 6, a second inlet section 7 and an outlet section 8.

[0028] In particular, the fuel gas G enters in the man-

ifold 1 through the first inlet opening 5 and the air A enters the manifold 1 through the second inlet opening 10. The air/gas mixture M exits the manifold 1 through the outlet opening 9 and is transferred to the burner 3 for the combustion. To suitably mix the air and the fuel gas, the manifold 1 comprises a mixer 11. The mixer 11 is located inside the frame structure 4 of the manifold 1 and allows the mixing at the mixer outlet 12. In other words, as described in more detail in figures 4A and 5A, the mixer 11 receives the fuel gas G from the first inlet section 6 and the air A from the second inlet section 7 and mix them at the mixer outlet 12. The mixer 11 is not an integral part of the frame structure 4 but can be inserted into or removed from the frame structure 4 through an opening, in particular the outlet opening 9 or the first inlet opening 5 or the second inlet opening 10 or another opening. For this purpose, the mixer 11 is shaped in accordance with the second inlet opening 10.

[0029] Figures 2A and 2B illustrate the frame structure 4 from a rear view (Fig. 2A) and from a front view (Fig. 2B). From the figures emerges that the frame structure 4 is a one-piece structure with a first inlet section 6, a second inlet section 7 and an outlet section 8. Figure 2A shows that functional components, such as the mixer 11 and the suppressor 13 can be advantageously inserted into the frame structure 4. The mixer 11 is located in a lower region of the frame 4 at the first inlet section 6 and at the second inlet section 7 (downstream these two sections) and can be inserted through an opening, in particular through one of the aforementioned openings. The suppressor 13 is located in an upper region of the frame 4 at the outlet section 8 (downstream the mixer 11) and can be inserted through the outlet opening 9.

[0030] As shown in figures 3A and 3B, the suppressor 13 is located in a dedicated seat 27 (first seat) inside a mixing chamber 26 arranged downstream the mixer 11. In particular, figure 3A shows the frame structure 4 according to a top view and figure 3B shows the frame structure 4 according to a side view. It is noted that the suppressor 13 can have a polygonal cross section in order to perfectly fit the first seat 27 in the mixing chamber 26, the first seat 27 also having a polygonal cross section. The suppressor 13 can be made of metal, for example aluminum, manufactured by tooling machines.

[0031] Figures 4A and 4B illustrate the structure of a mixer 11 according to one example. The mixer has a main body 17 having a polygonal cross section with a first region 14 for receiving fuel gas G from the first inlet section 6 of the manifold 1 and a second region 15 for receiving air from the second inlet section 7 of the manifold 1. The first region 14 is located in an upper portion of the main body 17 and extends transversally in the main body 17. The second region 15 basically extends overall the main body 17 of the mixer 11 and in particular it extends longitudinally in the main body 17. The mixer 11 can be a one single piece structure made of plastic material and realized using for example a stereolithographic 3D printer. Alternatively, the mixer 11 can be made of

metal, for example aluminium or brass.

[0032] It is noted that the main body 17 comprises, at the bottom, two engaging means 21 in the form of fins. These engaging means 21 can be coupled to corresponding (two) guiding means 22 present in the second inlet section 7 of the manifold 1 (see Fig. 2B). The guiding means 22 are in the form of elongated slots extending along an internal surface of the frame structure 4 at the profile of the second inlet opening 10. In this way, the mixer 11 can be easily inserted and guided in the frame structure 4 of the manifold 1. Also, the coupling of the engaging means 21 and the guiding means 22 allows the mixer 11 to be in the correct position during the operation of the combustion appliance. In particular, the coupling ensures that, once the mixer 11 is inserted into the manifold 1, the first region 14 of the mixer 11 is aligned with the first inlet section 6 and then with the first inlet opening 5 to correctly receive the fuel gas G and the second region 15 is aligned with the second inlet section 7 and then with the second inlet opening 10 to correctly receive air A.

[0033] The mixer 11 comprises an elongated hollow structure 16 located in the first region 14. The elongated structure 16 receives the fuel gas G from the gas inlet 18 and releases the received fuel gas from an outlet slot 19 at the mixer outlet 12. It is noted that the elongated structure 16 has a funnel shape. This shape serves to homogeneously distribute the fuel gas G at the mixer outlet 12. In fact, the elongated structure 16 extends transversally the main body 17 of the mixer 11 and the outlet slot 19 basically extends from one end to another end of the mixer outlet 12.

[0034] The elongated structure 16 and therefore the outlet slot 19 covers the mixer outlet 12 only in part. Accordingly, at the mixer outlet 12, the fuel gas G exiting from the outlet slot 19 meets the air A coming from the second inlet section 7 and passing through the second region 15 of the main body 17 and exiting at a region of the mixer outlet 12 not covered by the elongated structure 16 (i.e. laterally from the elongated structure 16). This produces an air/gas mixture M that is provided further in the manifold 1 and then in the burner 3. It is noted that the fuel gas enters the gas inlet 18 according to a first direction and exits through the outlet slot 19 according to a second direction, orthogonal to the first direction and parallel to the direction of the air flowing in the main body 17 of the mixer 11. In particular, at the mixer outlet 12 both fuel gas G and air A exit according to the same direction and are mixed to form an air/gas mixture M.

[0035] Figure 4B shows the mixer 11 according to a top view. As shown in the figure, at the mixer outlet 12, a cross-sectional gas flow area 23 is formed and extends in the center of the opening 12 (region with a squared pattern). Also, a cross sectional air flow area 24 is formed and extends laterally in the opening 12 (two regions with vertical lines pattern). The mixer 11 is designed to find a correct compromise between free air area and gas area and particularly to achieve the target in terms of heating

power and modulation ratio. This to ensure less pressure loss as possible. In terms of area, the ratio between the cross-sectional gas flow area 23 and the cross-sectional air flow area 24 at the mixer outlet 12 is comprised between 0.14 and 0.17, that is about between 1:6 and 1:7.

[0036] Figures 5A and 5B show a mixer 11 according to a different configuration. Indeed, the components of the mixer 11 and the mixing functioning is exactly the same as those in figure 4A and 4B. Therefore, the components description is not repeated here. The only difference lies in the different form of the outlet slot 19. In fact, whereas the outlet slot 19 of figures 4A and 4B comprises an increased outlet 20 at the gas inlet 18, the outlet portion 19 of figures 5A and 5B comprises an outlet portion 19 with constant dimensions (i.e. a rectangular slot). This serves to make the mixing at the mixer outlet 12 more homogeneous.

Reference Signs

[0037]

1. Manifold
 2. Combustion appliance
 3. Burner
 4. Frame structure
 5. First inlet opening
 6. First inlet section
 7. Second inlet section
 8. Outlet section
 9. Outlet opening
 10. Second inlet opening
 11. Mixer
 12. Mixer outlet
 13. Suppressor
 14. First region
 15. Second region
 16. Elongated structure
 17. Main body
 18. Gas inlet
 19. Outlet slot
 20. Increased aperture
 21. Engaging means
 22. Guiding means
 23. Cross-sectional gas flow area
 24. Cross-sectional air flow area
 25. Second seat
 26. Mixing chamber
 27. First seat
- A Air
G Fuel gas
M Air/gas mixture

Claims

1. Manifold (1) for a combustion appliance (2), in par-

tical for a gas boiler, for distributing an air/gas mixture to a burner (3) of said combustion appliance (2), the manifold (1) having a one-piece hollow frame structure (4) comprising:

- a first inlet section (6) for receiving fuel gas through a first inlet opening (5);
 - a second inlet section (7) for receiving air through a second inlet opening (10), the second inlet section (7) being located upstream the first inlet section (6); and
 - an outlet section (8) for releasing the air/gas mixture to the burner (3) through an outlet opening (9), the outlet section (7) being located downstream the first inlet section (6) and the second inlet section (7);
 - wherein the manifold (1) comprises a mixer (11) for allowing the mixing of the fuel gas and air at a mixer outlet (12).
2. Manifold (1) according to claim 1, **characterized in that**
- a. the mixer (11) is insertable into the frame structure (4) through an opening, in particular the second inlet opening (10), and/or **in that**
 - b. the mixer (11) comprises a main body (17) having a first region (14) for receiving fuel gas from the first inlet section (6) and extending transversally in the main body (17) and/or a second region (15) for receiving air from the second inlet section (7) and extending longitudinally in the main body (17).
3. Manifold (1) according to claim 2, **characterized in that** the mixer (11) comprises an elongated hollow structure (16) located in the first region (14), said elongated structure (16) comprising a gas inlet (18) coupled to the first inlet section (6) and an outlet slot (19) for releasing the fuel gas at the mixer outlet (12).
4. Manifold (1) according to claim 3, **characterized in that**
- a. the elongated structure (16) has a funnel shape; and/or
 - b. the outlet slot (19) of the elongated structure (16) at the gas inlet (18) has an increased aperture (20).
5. Manifold (1) according to any one of claims 1 to 5, characterized
- a. the mixer outlet (12) has a polygonal cross section, in particular a rectangular cross-section; and/or
 - b. the main body (17) of the mixer (11) has a polygonal cross section, in particular a rectan-

gular cross-section; and/or

c. the second inlet opening (10) has a polygonal shape, in particular a rectangular shape.

- 5 6. Manifold (1) according to any one of claims 1 to 5, **characterized in that** the mixer (11) comprises one or more engaging means (21), in particular pins or fins, and the second inlet section (7) comprises one or more guiding means (22), in particular seats or slots, for allowing the positioning and guiding of the mixer (11) inside the manifold (1).
- 10 7. Manifold (1) according to any one of claims 1 to 6, **characterized in that** at the mixer outlet (12) a cross-sectional gas flow area (23) and a cross-sectional air flow area (24) are present, wherein
- 15 a. the cross-sectional gas flow area (23) at the mixer outlet (12) is smaller than the cross-sectional airflow area (24); and/or
- 20 b. the ratio between the cross-sectional gas flow area (23) and the cross-sectional air flow area (24) at the mixer outlet (12) is comprised between 0.14 and 0.17.
- 25 8. Manifold (1) according to any one of claims 1 to 7, **characterized in that** the manifold (1) further comprises a suppressor (13) located in the frame structure (4) downstream the mixer (11) for avoiding a flame back in the manifold (1).
- 30 9. Manifold (1) according to any one of claims 1 to 8, **characterized in that** the manifold (1) further comprises a mixing chamber (26) positioned downstream the mixer (11), in particular between the mixer outlet (12) and the outlet opening (9) of the outlet portion (8), for mixing the fuel gas and the air received from the mixer (11).
- 35 10. Manifold (1) according to claims 8 and 9, **characterized in that** the manifold (1) further comprises a first seat (27) for positioning the suppressor (13), the first seat (27) being located in the mixing chamber (26).
- 40 11. Manifold (1) according to any one of claims 1 to 10, **characterized in that** the second inlet section (7) of the manifold (1) is, in particular directly, connectable to a fan element.
- 45 12. Manifold (1) according to any one of claims 1 to 11, **characterized in that** the manifold (1) further comprises a second seat (25) for a, in particular mass, flow sensor for monitoring a, in particular mass, flow rate, the second seat (25) being located at the first inlet section (6) downstream the first inlet opening (5).
- 50 13. Manifold (1) according to any one of claims 1 to 12,
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characterized in that the manifold (1) further comprises a gas regulation valve to limit the maximum gas flow in the manifold (1).

14. Combustion appliance (2), in particular a gas boiler, comprising a manifold (1) according to any one of claims 1 to 13. 5

15. Use of a manifold (1) according to any one of claims 1 to 13 in a combustion appliance (2) for the combustion of fuel gas, in particular comprising at least 20 mol% hydrogen, in particular pure hydrogen, or natural gas or mixtures thereof. 10

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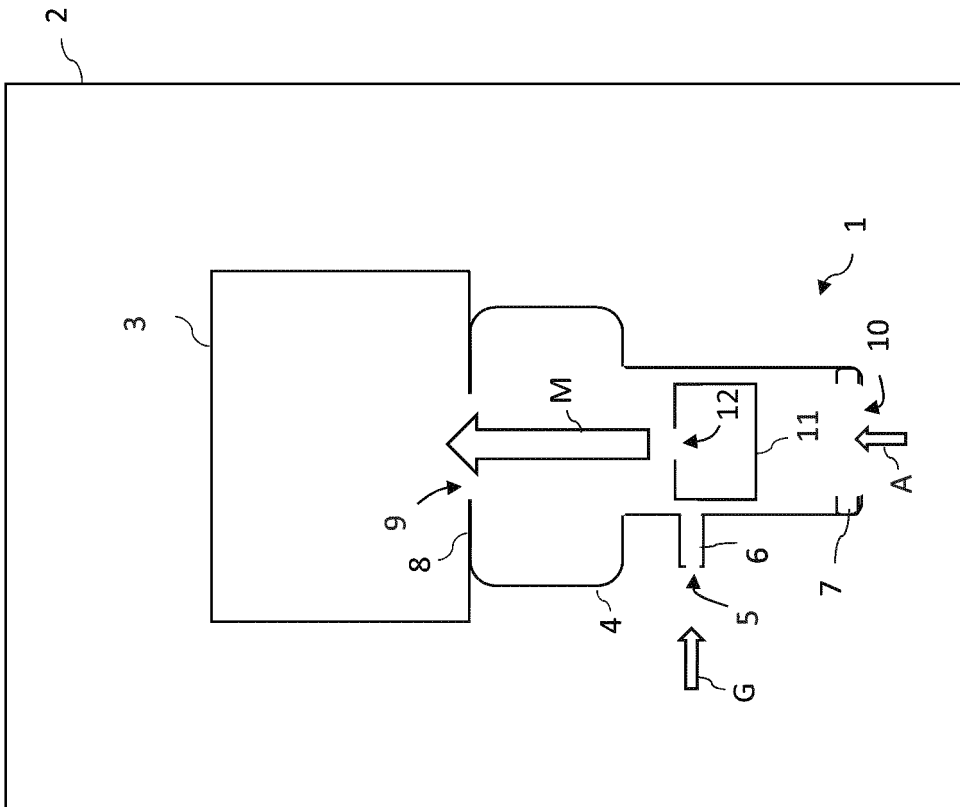


FIG. 1

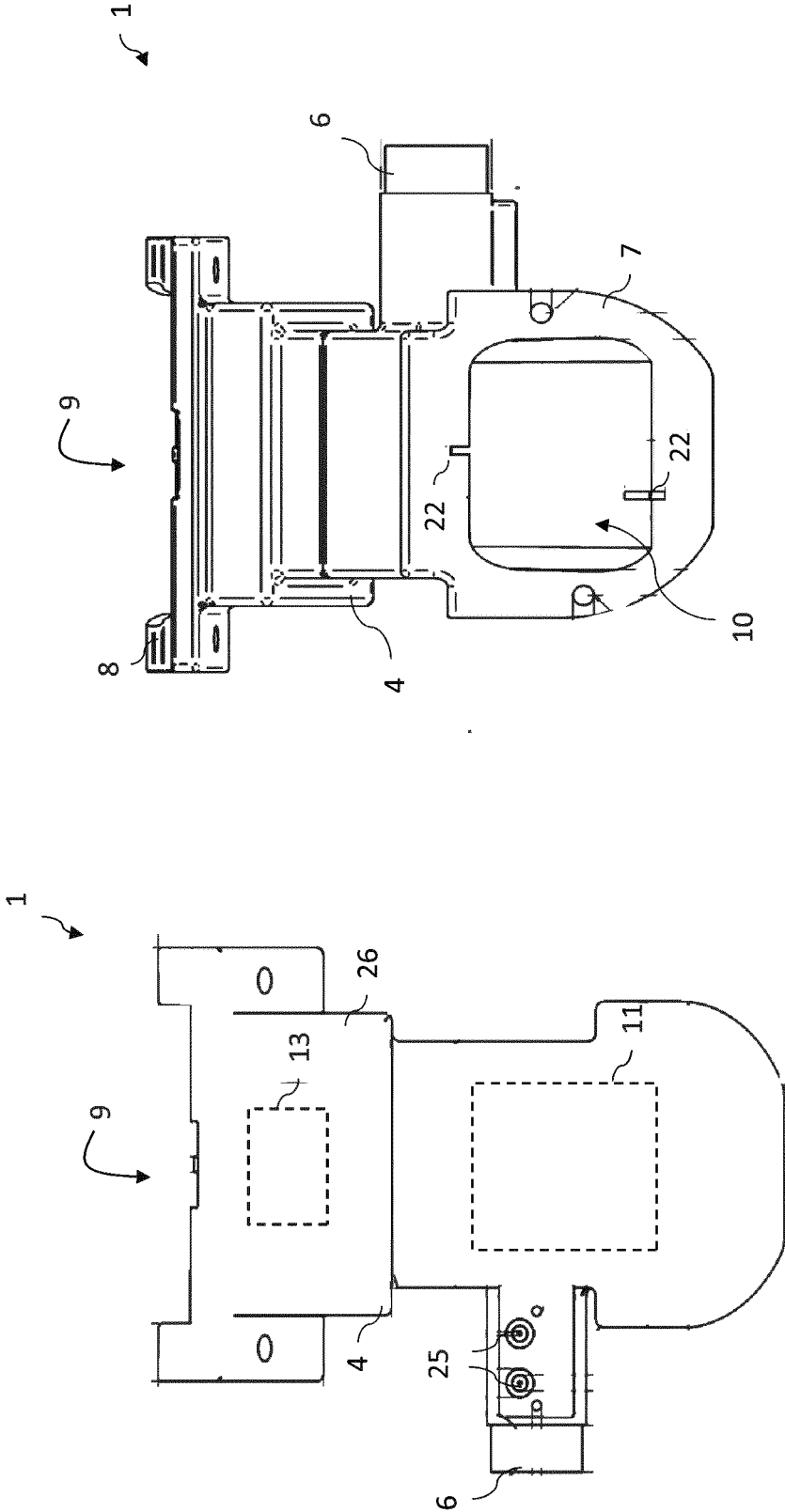


FIG. 2A

FIG. 2B

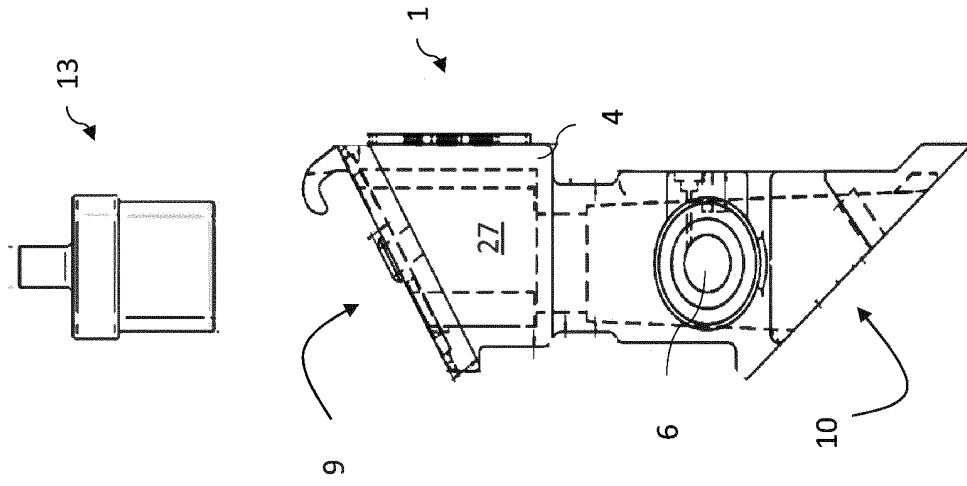


FIG. 3B

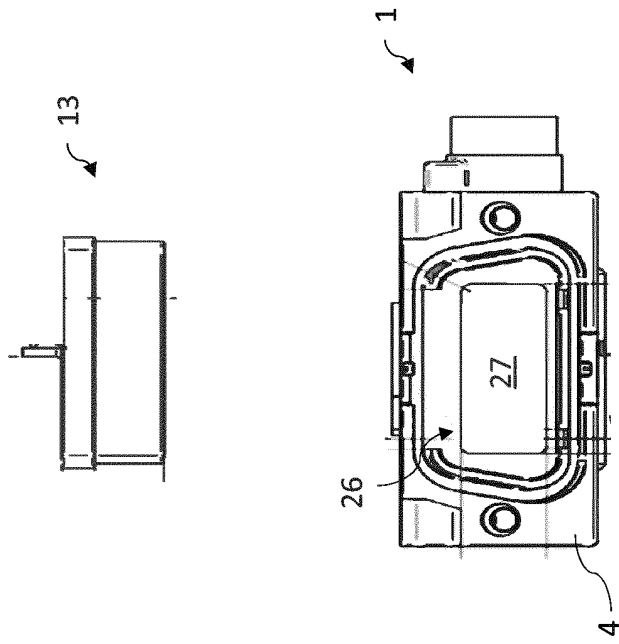


FIG. 3A

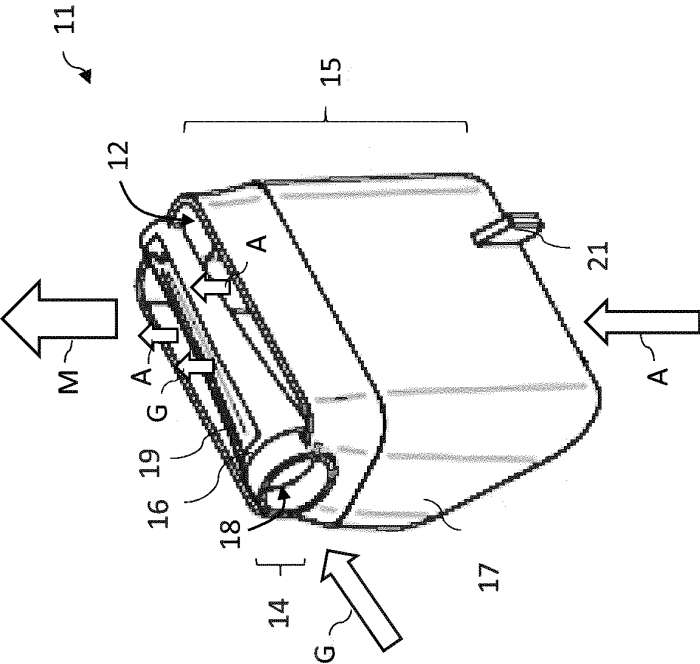


FIG. 4A

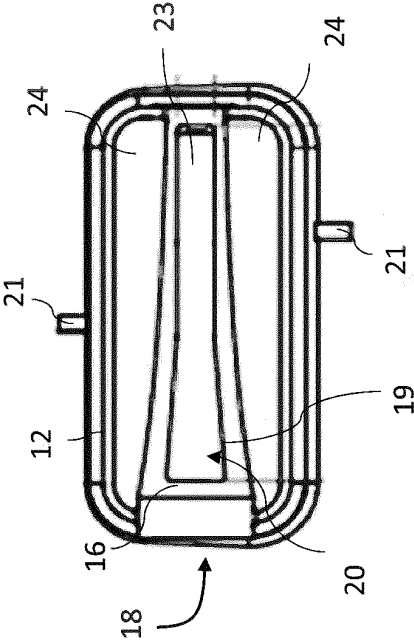


FIG. 4B

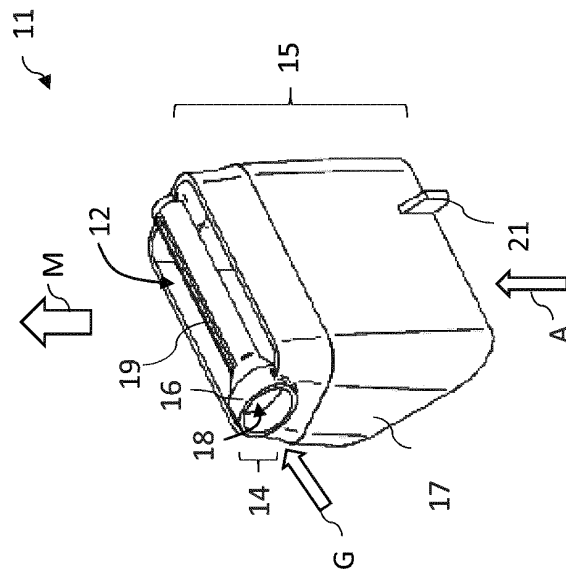


FIG. 5A

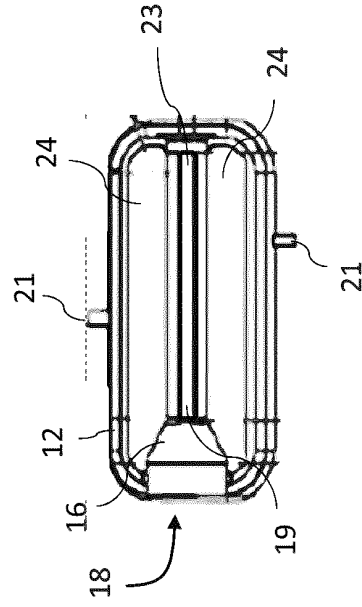


FIG. 5B



EUROPEAN SEARCH REPORT

Application Number

EP 22 16 0009

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EPO FORM 1503 03.82 (P04C01)

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 2011/044868 A1 (LEE YONGIL [KR] ET AL) 24 February 2011 (2011-02-24) * page 2, paragraph 27 - page 3, paragraph 46 * * figure 1 *	1, 2, 6-10, 12-15	INV. F23D14/02 F23D14/62 F23D14/82
X	US 10 808 927 B2 (CLEARSIGN COMB CORP [US]; CLEARSIGN TECH CORPORATION [US]) 20 October 2020 (2020-10-20) * column 3, line 42 - column 4, line 34 * * figures 1A, 1B *	1, 2, 5, 8, 9, 13-15	
X	US 2020/284473 A1 (DAL GAZZO MARCO [IT] ET AL) 10 September 2020 (2020-09-10) * page 2, paragraph 35 - page 3, paragraph 38 * * figure 1 *	1-4, 9, 11, 14, 15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F23D F23C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 29 August 2022	Examiner Gavriliu, Costin
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 22 16 0009

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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