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(54) **AN ARRANGEMENT FOR COMBUSTING PURGE GAS AND A METHOD THEREOF**
ANORDNUNG ZUR VERBRENNUNG VON SPÜLGAS UND VERFAHREN DAFÜR
AGENCEMENT DE COMBUSTION DE GAZ DE PURGE ET PROCÉDÉ ASSOCIÉ

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Description

Field of the invention

[0001] The invention relates to an arrangement for combusting purge gas originating from an ammonia fuel system fueling an ammonia fueled engine and a method thereof.

Background art

[0002] Marine engines powered by oil or gas are well known in the art. Oil and gas fired boilers for marine steam production are also well known in the art. Usually, the choice of fuel for the boiler operation is made in relation to the fuels selected for the marine engine operation. Thus, if the marine engine is powered by oil, the boiler is often powered by oil as well. However, the marine engine and the boiler may be powered by different fuels.

[0003] One drawback with most of the marine engines of today is marine air pollution, especially carbon dioxide (CO₂), emitted from the marine engines when providing propulsion power. It is generally agreed that the CO₂ emissions, as well as other greenhouse gas emissions, have to be decreased in view of environmental aspects. As a solution, alternative fuels are gaining traction in the marine industry. This includes fuels like methanol, hydrogen, ammonia or conversion of biomaterials. However, by introducing alternative fuels, other problems may occur, e.g. other environmental problems. For instance, by powering the marine engines with some of the alternative fuels, gases originating from those fuels may e.g. often not be directly vented to the atmosphere e.g. because of toxicity and need often be eliminated before being vented to the atmosphere. This latter is e.g. the case when ammonia is used as fuel. Thus, although the alternative fuels may be more environmentally friendly regarding greenhouse gas emissions compared to the conventional fuels, there are still other problems that need to be overcome.

[0004] In attempt to address some parts of this issue, document CN109140496 discloses a boiler ignition device using ammonia purge gas as a heat source including a purge gas supply pipeline and ignition gas supply pipeline.

[0005] However, as will be explained below, the prior art does not disclose a more environmentally friendly marine arrangement which adequately addresses the set of design criteria of making it possible to use alternative fuels and at the same time provide for that no, or limited amounts of, toxic gases are vented to the atmosphere, and especially the prior art does not disclose how to provide an overall arrangement which may be used in a convenient manner over time when it comes to meeting said set of design criteria.

[0006] US2014/0248202 discloses a process for incinerating ammonia in an incinerator comprising a first and a second incineration step.

[0007] US4519993 discloses a process for disposal of a waste stream comprising burning the waste stream to provide a combustion effluent and reacting the combustion effluent with an oxygen containing gaseous stream.

Summary of the invention

[0008] It is an object of the invention to provide a more environmentally friendly marine arrangement which adequately addresses the set of design criteria of making it possible to use alternative fuels and at the same time provide for that no, or limited amounts of, toxic gases are vented to the atmosphere.

[0009] This object has been achieved by an arrangement for combusting purge gas originating from an ammonia fuel system fueling an ammonia fueled engine, the arrangement comprising:
a boiler system comprising

a burner,
a fuel inlet configured to supply a fuel and thereby sustain a support flame in the burner, and
a purge gas inlet being configured to intermittently receive purge gas from the ammonia fuel system and supply the purge gas to the burner, the purge gas comprising a mixture of ammonia and inert gas, wherein the burner is configured to combust the ammonia with the support flame.

[0010] Preferably, the ammonia fueled engine is a marine engine. The ammonia fueled engine is advantageous as it uses a more environmentally friendly fuel, namely the ammonia, for powering the engine compared to most fossil fuels used today, e.g. oil and gas. The arrangement is advantageous as it combusts the purge gas originating from the ammonia fuel system instead of venting the purge gas into the atmosphere. The purge gas may be generated when the ammonia fueled engine switches fuel from ammonia to another fuel or when the ammonia fueled engine shuts down, either in a controlled manner or as a result of an emergency situation. At this stage, the purge gas is toxic and should therefore not be vented to the atmosphere. Instead, the purge gas inlet receives the purge gas originating from the ammonia fuel system and supplies the purge gas to the burner. By burning the mixture in the burner, the purge gas is vented to the atmosphere as a combustion gas primarily consisting of nitrogen and water instead of as a toxic gas. Thus, the arrangement may be said to act as a safety mechanism by burning the purge gas in the burner instead of venting toxic gases to the atmosphere. Thus, a more environmentally friendly marine arrangement using alternative fuels, namely the ammonia, and at the same time provides for that no, or as little as possible, toxic gases is vented to the atmosphere is achieved.

[0011] Preferably, the ammonia fueled engine is operating on ammonia in pure form. However, it should be noted that the ammonia may comprise minor amount of

water. It should further be noted that the ammonia may be mixed with another fuel e.g. an alcohol like methanol or ethanol or a gas like hydrogen. Mixing the ammonia with another fuel may be advantageous if the ammonia is too difficult to combust with the support flame.

[0012] The purge gas may comprise a mixture of ammonia and inert gas. The inert gas may be nitrogen. Preferably, the nitrogen is compressed nitrogen. However, it should be noted that other inert gases may be used as well. It should further be noted that if the ammonia is mixed with another fuel, the purge gas will comprise the other fuel as well. The fuel may initially be supplied to provide a pilot flame and may also, when the burner is running in operational mode, be supplied as a main fuel. When the fuel is supplied to provide the pilot flame, the fuel may be of a small amount such that a small flame for ignition of a main fuel may be provided. The pilot flame may be for igniting the fuel being supplied as the main fuel. When the fuel is supplied as the main fuel, the fuel is supplied at a greater amount compared to the fuel supplied for provide the pilot flame. Preferably, when combusting the ammonia, the main fuel is acting as the support flame such that the purge gas is combusted with the support flame. The support flame has to be of a certain size to ensure fully combustion of the ammonia.

[0013] Preferably, the boiler may, when activated to combust purge gas, run in 15-50%, preferably 25-50%, compared to full operation in the sense that the support flame may be sustained by providing a fuel at a rate of 15-50%, preferably 25-50%, compared to the rate at which the fuel is provided when the boiler runs at full operation, thereby making sure that the ammonia supplied to the burner is combusted also when the burner is activated for the purpose of combusting purge gas and not activated an run in full operation to produce heat. In this context it may be noted that production of heat may refer to production of steam, heating hot water, heating a thermal fluid or heating any other media used in the boiler. The support flame typically has to be larger than the pilot flame because the purge gas is typically more difficult to ignite compared to the main fuel. The fuel inlet and the purge gas inlet may be separate inlets. However, which will be discussed further below, if the purge gas comprises both gas and liquid, the liquid may be supplied to the burner by the fuel inlet and the gas may be supplied to the burner by the purge gas inlet.

[0014] The burner may be a of a steam atomizing type or a pressure atomizing type. It should be noted that the fuel may be supplied to provide the pilot fuel for igniting the main fuel if the burner is of the steam atomizing type. If the burner is of the pressure atomizing type, the fuel is typically only supplied as the main fuel. Instead, the pressure atomizing burner comprises a spark igniter configured to igniting the main fuel. However, if the burner is of the steam atomizing type, the fuel may be supplied to provide the pilot flame as the spark igniter for igniting the main fuel.

[0015] The boiler system may be configured to operate

in one of at least a first mode and a second mode, wherein

the first mode is a heat production mode in which heat is produced, and

the second mode is an ammonia safety purge mode in which a boiler is kept warm and ready for fast operation and/or in which a pilot flame is sustained.

[0016] The first mode may be the operational mode discussed above. The second mode may be a ready mode, wherein the boiler is ready for fast operation or ready for fast start-up. In the first and the second mode, the burner may be an active burner. By the term "active burner" is here meant a burner that is ready for receiving the purge gas via the purge gas inlet at any time because the shutdown of the engine may occur at any time. If the burner is an active burner, the burner is in operation mode or in ready mode, ready to receive the purge gas.

[0017] The disclosed boiler system provides for that a more flexible boiler system is achieved. By having a more flexible boiler system, it is possible to use the boiler system in more ways than just the main purpose of the burner, namely, to produce heat. The boiler system may thus be configured to combust the purge gas as well. The switch between the different modes provides for that the conventional burner, e.g. an oil-fired burner or a gas-fired burner, may be used for both producing heat but also to combust the purge gas. However, it should be noted that the burner may be configured to operate in more than the two modes.

[0018] The boiler system may be configured to operate in one of at least a first sub-mode and a second sub-mode of the first mode, wherein, in the first sub-mode, a main flame is sustained in the burner for heat production and no purge gas is supplied to the burner, and, in the second sub-mode, the main flame is sustained in the burner for heat production and purge gas is supplied to the burner and the ammonia is combusted with the main flame acting as the support flame.

[0019] The first sub-mode of the first mode may be configured to produce heat from the main fuel. The second sub-mode of the first mode may be configured to produce heat from the main fuel and the purge gas, thereby combust the purge gas.

[0020] The boiler system may be configured to ignite a support flame by first igniting a pilot flame and then igniting the support flame from the pilot flame or, if a pilot flame is sustained, directly ignite the support flame from the pilot flame and to supply purge gas to the burner and combust the ammonia with the support flame.

[0021] Preferably, the respective inlets may be controlled by one or more valves. The one or more valves may be configured to open and close the fuel inlet and the purge gas inlet such that the switch between the at least two modes and/or between the first and second sub-mode of the first mode may be possible. The one or more valves may be configured to independently open and

close the fuel inlet and independently open and close the purge gas inlet.

[0022] The fuel inlet may be connected via a fuel supply line to a fuel source, the fuel source may be configured to supply the fuel selected from the group consisting of liquefied natural gas (LNG), distillate and residual fuels. This may e.g. include diesel, marine gas oil (MGO), very low Sulphur fuel oil (VLSFO), heavy fuel oil (HFO). The fuel may also be a biofuel. It should be noted that other type of fuels may be used as the fuel as well such as ammonia, hydrogen, and methanol. It should be noted that the fuel may comprise two types of fuel. The two types of fuel may be premixed with each other and supplied from the same fuel source or may be kept separate and be supplied from two different fuel sources. The fuel sources may e.g. be tanks. If the fuel comprises two types of fuel, being supplied from two different fuel sources, they may have one supply line each from the respective fuel tank to the burner, but they may share as well. If the two types of fuels being supplied from two different fuel sources with a supply line each, they may also have a fuel inlet each, or alternatively there is one fuel inlet which is connected to the two different supply lines such that the fuels from the two different fuel sources may be introduced into the burner the common inlet. The other fuel source may be configured to supply the fuel selected from the group consisting of liquefied natural gas (LNG), distillate and residual fuels. This may e.g. include diesel, marine gas oil (MGO), very low Sulphur fuel oil (VLSFO), heavy fuel oil (HFO). The fuel may also be a biofuel. It should be noted that other type of fuels may be used as the fuel as well such that ammonia, hydrogen, and methanol.

[0023] The arrangement further comprises the ammonia fuel system, the ammonia fuel system comprising:

- an ammonia fuel source for storing ammonia,
- a fuel supply system,
- the ammonia fueled engine, and
- a purge source which contains the inert gas, and which is configured to purge ammonia from parts of the ammonia fuel system to the purge gas inlet by flushing the inert gas through the parts of the ammonia fuel system.

[0024] This is advantageous as it ensures that there is no unwanted fuel in pipelines of the ammonia fuel system. Thus, when the ammonia fuel engine switches fuel or shuts down, as previously discussed, there may be ammonia in the pipelines that should not be vented to the atmosphere nor being supplied back to the ammonia fuel source. By flushing the inert gas through those parts of the ammonia fuel system, the ammonia that may be left in the pipelines is forced out of the ammonia fuel system, forming a mixture of ammonia and the inert gas, and this mixture may be directed towards the boiler system. The mixture may e.g. be directed via an evaporator and/or a separator to take into account that the mixture of ammo-

nia and the inert gas may also be a mixture of gas and liquid phase. Forcing the ammonia out of the ammonia fuel system by the inert gas provides for that more or less all ammonia is vented from the ammonia fuel system. Thereby, a more secure and environmentally friendly arrangement is achieved.

[0025] The ammonia may be purged from parts of the ammonia fuel system. Preferably, the ammonia may be purged from parts being close to the engine because it may be dirty ammonia within these parts, and it should be avoided to mix dirty ammonia back to the ammonia fuel source.

[0026] Preferably, the ammonia forced out of the ammonia fuel system should not be able to be forced to other parts within the ammonia fuel system, but out from the system. The ammonia fuel system may comprise one or more valves configured to control the flow of the ammonia when the ammonia is being forced out of the ammonia fuel system.

[0027] The arrangement may further comprise fuel valve train and recirculation taking care of the ammonia that do not have to be purged. This may e.g. typically be ammonia present in those parts of the ammonia fuel system being comparably close to the fuel tank. Such ammonia has typically not picked up too much dirt and water and may typically be returned to the fuel tank.

[0028] The mixture of ammonia and inert gas may comprise gaseous ammonia, liquid ammonia, and inert gas.

[0029] The arrangement may further comprise an evaporator configured to evaporate liquid ammonia into gaseous ammonia thereby providing a gaseous mixture of ammonia and inert gas to be supplied to the burner. That the mixture comprises both liquid and gaseous ammonia is typically not optimal for the burner. Thus, the burner typically needs either a liquid or a gas but does typically not work well with a mixture of both. Therefore, if the mixture may comprise both liquid and gas, it may need to be transformed to either one of liquid or gas. By introducing the evaporator in the arrangement, it may be possible to evaporate the liquid ammonia to gaseous ammonia such that the purge supplied to the burner may only comprise the purge gas. Thus, the evaporator may be advantageous in that it provides for that only gaseous purge is received by the burner. Preferably, the evaporator is arranged such that the purge gas is supplied to the evaporator before being supplied to the purge gas inlet.

[0030] The arrangement may further or alternatively comprise a separator configured to separate the liquid ammonia from the gaseous ammonia and inert gas thereby providing a gaseous mixture of ammonia and inert gas to be supplied to the burner. By introducing the separator in the arrangement, it may be possible to separate the liquid ammonia from the gaseous ammonia and the inert gas such that the purge supplied to the burner may only comprise the purge gas. The separator may be a gas/liquid separator, typically a drum or tank with a demister in an outlet. The liquid phase of the purge may be

connected to main fuel supply system such that the liquid phase is mixed with a liquid main fuel. It should be noted that the arrangement may comprise both the evaporator and the separator, or only one of them.

[0031] The evaporator may e.g. be arranged downstream of the separator such that the purge gas from which most of the liquid phase has been removed in the separator is supplied to the evaporator before being supplied to the purge gas inlet.

[0032] The burner may be a multi-fuel burner configured to burn at least two different fuels one at the time or simultaneously. This is advantageous in that more than one fuel may be configured to power the burner or to be burned by the burner. The multi-fuel burner may be configured to burn at least two different fuels, preferably two different liquid fuels, preferably one at the time. The multi-fuel burner may be configured to burn one or more liquids fuels in combination with burning one or more gaseous fuels, wherein the one or more liquid fuels, preferably one liquid fuel at the time, is burnt simultaneously as the one or more gaseous fuels, preferably one gaseous fuel at the time, is burnt.

[0033] The arrangement may further comprise a liquid ammonia inlet being connected via a liquid ammonia connection to the fuel supply line such that the liquid ammonia is mixed with the fuel. This may be advantageous if the arrangement comprises the separator and/or the evaporator. If that is the case, the liquid ammonia separated from the purge gas may be configured to be mixed with the fuel and still reach the burner, but in a different mixture compared to the purge gas mixture.

[0034] The arrangement may further comprise a combustion fan configured to provide combustion air to the burner. The combustion fan may be configured to supply a specific amount of combustion air, based on pre-set requirements. Preferably, there should be 10-15% more combustion air than fuel in the boiler system. This ratio of combustion air is typically needed to have a complete combustion of the fuel but also of the purge gas. If the combustion is not complete, it may lead to dirty furnace and black exhaust gas with higher carbon oxide, CO, content than wanted.

[0035] The arrangement may further comprise a gas valve train configured to control the flow of the purge gas being supplied to the burner from the ammonia fuel system.

[0036] The combustion fan may further or alternatively be configured to direct the purge gas to the burner. The combustion fan may comprise the purge gas inlet, wherein the combustion fan may be configured to mix the purge gas with combustion air and to provide the mixture of purge gas and combustion air to the burner.

[0037] If the combustion fan is configured to direct the purge gas to the burner, the gas valve train may be excluded from the arrangement. Instead, the combustion fan may be arranged to control and direct the flow of the purge gas being supplied to the burner from the ammonia fuel system. In the combustion fan, the purge gas may

be mixed with the combustion air. The mixture may be directed to the burner, wherein the mixture may be combusted with the support flame. However, it should be noted that the arrangement may comprise both the combustion fan for directing the purge gas and the gas valve train. The combustion fan may be designed for purge gas. The purge gas inlet comprised in the combustion fan may ensure optimal mixture with the combustion air. In addition, the combustion fan may be arranged to prevent back flow of the purge gas.

[0038] Further, if the arrangement comprises the evaporator and/or the separator, the combustion fan is preferably arranged downstream the evaporator and/or the separator.

[0039] The above-mentioned object has also been achieved by a method for combusting purge gas originating from an ammonia fuel system fueling an ammonia fueled engine, the method comprising:

sustaining a support flame in a burner comprised in a boiler system, wherein the support flame is sustained by a fuel supplied by a fuel inlet; and intermittently supplying the purge gas, wherein the purge gas is supplied by a purge gas inlet from the ammonia fuel system to the burner, the purge gas comprising a mixture of ammonia and inert gas, and combusting the ammonia in the burner with the support flame.

[0040] In accordance with the method, the boiler system may be configured to operate in one of at least a first mode and a second mode, wherein

the first mode is a heat production mode in which heat is produced, and
the second mode is an ammonia safety purge mode in which the boiler is kept warm and ready for fast operation and/or in which a pilot flame is sustained.

[0041] The further different preferred embodiments mentioned above in relation to the arrangement are equally applicable to the method.

[0042] The arrangement is preferably placed onboard a ship. The method is preferably performed onboard a ship. However, it may be noted that neither the arrangement, nor the method, is limited to be used onboard ship. The arrangement and the method may be useful for other applications where there is an engine and a boiler positioned nearby each other. This may e.g. be the case, apart from ships, in other marine applications. It may e.g. be platforms, such as platforms of the kind used for drilling for oil or gas. The arrangement and method may also be useful for land-based applications. The arrangement and method may e.g. be used for logging or mining applications.

[0043] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein.

All references to "a/an/the [element, device, component, means, step, etc.]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

Brief Description of the Drawings

[0044] The above, as well as additional objects, features and advantages of the present invention, will be better understood through the following illustrative and non-limiting detailed description of preferred embodiments of the present invention, with reference to the appended drawings, where the same reference numerals will be used for similar elements, wherein:

Figure 1 discloses an arrangement for combusting purge gas originating from an ammonia fueled engine.

Figure 2 discloses a flow chart illustrating a method for combusting purge gas originating from an ammonia fueled engine.

Description of Embodiments

[0045] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred embodiments of the invention are shown. This disclosure may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided for thoroughness and completeness, and fully convey the scope of the invention to the skilled person.

[0046] With reference to figure 1, there is disclosed an arrangement 100 for combusting purge gas originating from an ammonia fuel system 108 fueling an ammonia fueled engine 112. The arrangement 100 comprises a boiler system 102 and an ammonia fuel system 108. The ammonia fuel system 108 comprises the ammonia fueled engine 112.

[0047] The purge gas may be generated when the ammonia fueled engine 112 switches fuel from ammonia to another fuel or when the ammonia fueled engine 112 shuts down, either in a controlled manner or as a result of an emergency situation. At this stage, the purge gas is toxic and should therefore not be vented to the atmosphere. The purge gas is typically a mixture of ammonia and an inert gas used to purge the ammonia from the ammonia fuel system 108. The ammonia may be liquid ammonia, gaseous ammonia, or a mixture thereof. The inert gas may be nitrogen. It should be noted that the inert gas may be any other inert gases as well.

[0048] The boiler system 102 comprises a burner 104, a fuel inlet 111 and a purge gas inlet 121. The burner 104 is configured to burn the purge gas originating from

the ammonia fuel system 108. Put differently, the burner 104 is configured to combust the ammonia within the purge gas. The burner 104 may be a multi-fuel burner configured to burn two different fuels one at the time or simultaneously. The burner 104 may be of pressure atomizing type. The burner 104 may alternatively be of steam atomizing type.

[0049] The fuel inlet 111 is configured to supply a fuel and thereby sustain a support flame in the burner 104. The fuel inlet 111 is typically configured to continuously supply the fuel, and at least continuously in the sense that it is capable of sustaining the support flame. The fuel may initially be supplied to provide a pilot flame and may also, when the burner is running in operational mode, be supplied as a main fuel. The main fuel may be acting as the support flame such that the purge gas may be combusted with the support flame.

[0050] The purge gas inlet 121 is preferably separated from the fuel inlet 111. The purge gas inlet 121 is configured to intermittently receive the purge gas from the ammonia fuel system 108 and supply the purge gas to the burner 104. The purge gas may be supplied from the ammonia fuel system 108 to the purge gas inlet 121 via a purge gas piping 123. The piping 123 may be of double-walled type; especially for those parts of the piping 123 where the purge is in gas phase.

[0051] The fuel inlet 111 may be connected via a fuel supply line 113 to a fuel source 115, e.g. a fuel tank. The fuel source 115 is configured to supply the fuel, via the fuel inlet 111, to the burner 104. The fuel may be liquefied natural gas (LNG), distillate and residual fuels. This may e.g. include diesel, marine gas oil (MGO), very low Sulphur fuel oil (VLSFO), heavy fuel oil (HFO). The fuel may also be biofuel. However, it should be noted that the main fuel may be other fuels as well. The fuel may comprise one or more type of fuels. If the fuel comprises more than one type of fuel, the fuel inlet 111 may be connected to more than one fuel sources. Thus, if the fuel comprises two types of fuel, one fuel type may be supplied from the fuel source 115 and the other fuel type may be supplied from one other fuel source 135. Typically, the fuels are supplied to the burner 104 only one at a time. Typically, the fuel supply line 113 is operated, as illustrated in Fig. 1, in that the different fuels are provided one at a time making use of the same inlet 111, albeit at different times. One conceivable combination is to provide a liquid fuel via the fuel supply line 113 to the inlet 111 and to simultaneously provide a gas via a separate gas inlet, such as via the combustion fan 120. The gas provided via separate gas inlet, such as the combustion fan 120, may be the purge gas and/or it may be a gaseous fuel not originating from the purging operation.

[0052] However, the fuel supply line 113 as illustrated in Fig. 1, may if so would be desired be used to mix the two types of fuel in the fuel supply line 113, wherein the other fuel may be supplied by one other fuel supply line 133 to the fuel supply line 113, such that the mixture is supplied to the burner 104 via the fuel inlet 111. However,

although not illustrated, the two types of fuel may be supplied to the burner 104 by two different fuel inlets via two different supply lines. Thus, the arrangement 100 may comprise an additional supply line being arranged separately from the fuel supply line 113, wherein the additional supply line may be arranged to supply the other fuel from the other fuel source 135 to the burner 104. The other fuel may be any of the fuels listed above regarding the fuel. Preferably, if the fuel comprises two types of fuel, one type may be a liquid fuel and the other type may be a gaseous fuel.

[0053] With reference to figure 2, a flow chart 200 illustrating a method 200 for combustion of the purge gas originating from the ammonia fuel system 108 fueling the ammonia fueled engine 112 is shown by way of example. The boiler system 102 is configured to operate in a first mode 201. The boiler system 102 is configured to operate in a second mode 211. The boiler system 102 may be configured to operate in other modes than the first mode 201 and the second mode 211. The first mode 201 may be a heat production mode in which heat is produced. In this context it may be noted that production of heat may refer to production of steam, heating hot water, heating a thermal fluid or heating any other media used in the boiler. The second mode 211 may be an ammonia safety purge mode in which a boiler 106 is kept warm and ready for fast operation and/or in which the pilot flame may be sustained. The boiler 106 is comprised in the boiler system 102. In the second mode 211, the boiler may be ready for fast operation or ready for fast start up.

[0054] The boiler system 102 may be configured to operate in a first sub-mode 201a and a second sub-mode 201b of the first mode 201. In the first sub-mode 201a, a main flame is sustained in the burner 104 for heat production and no purge gas is supplied to the burner 104. The first sub-mode 201a is configured to produce heat from the fuel supplied by the fuel inlet 111 to the burner 104. The second sub-mode 201b of the first mode 201 is configured to produce heat from the main fuel and the purge gas, wherein the purge gas is supplied by the purge gas inlet 121. Thus, in the second sub-mode 201b, the main flame is sustained in the burner 104 for heat production and purge gas is supplied to the burner 104. The ammonia is combusted with the main flame acting as the support flame.

[0055] The boiler system 102 is configured to ignite a support flame by first igniting a pilot flame or a pilot spark and then igniting the support flame from the pilot flame. The boiler system 102 is configured to, if a pilot flame is sustained, directly ignite the support flame from the pilot flame and to supply purge gas to the burner 104 and combust the ammonia with the support flame.

[0056] Thus, both the first and the second mode is configured to combust the ammonia but with different starting points.

[0057] Referring back to Fig. 1, the ammonia fuel system 108 comprises an ammonia fuel source 155, a fuel supply system 110 and the ammonia fueled engine 112.

The ammonia fuel system 108 may comprise a purge source 165. The ammonia fuel source 155 may be an ammonia tank and is configured to store the ammonia before being supplied to the ammonia fueled engine 112.

The fuel supply system 110 is configured to supply the ammonia within the ammonia fuel system 108. The ammonia fueled engine 112 is configured to be powered by the ammonia supplied from the ammonia fuel source 155.

[0058] The purge source 165 is typically a gas tank containing inert gas. The inert gas from the purge source 165 is configured to purge ammonia from the ammonia fuel system 108 to the purge gas inlet 121 by flushing the inert gas through the ammonia fuel system 108. The arrangement 100 may comprise a gas valve train 118 configured to control the flow of the purge gas being supplied from the ammonia fuel system 108 to the burner 104. As discussed above, the purge gas is a mixture of ammonia and inert gas. The ammonia may be liquid ammonia, gaseous ammonia, or a mixture thereof. If the ammonia is a mixture of gaseous ammonia and liquid ammonia, the purge gas is a mixture of gas and liquid. The purge gas supplied to the burner 104 should be in gaseous form and therefore, the liquid has to be removed from the purge gas before being supplied to the burner 104.

[0059] The arrangement 100 may comprise an evaporator 114 configured to evaporate liquid ammonia, if present in the mixture, into gaseous ammonia. By evaporating liquid ammonia into gaseous ammonia, a gaseous mixture of ammonia and inert gas may be supplied to the burner 104. The evaporator 114 may be arranged within the purge gas piping 123, between the boiler system 102 and the ammonia fuel system 108.

[0060] The arrangement 100 may further or alternatively comprise a separator 116 configured to separate liquid ammonia from the gaseous ammonia and inert gas, if present in the mixture. By separating liquid ammonia from the gaseous ammonia and the inert gas, a gaseous mixture of ammonia and inert gas may be supplied to the burner 104. The separator 116 may be arranged within the purge gas piping 123, between the boiler system 102 and the ammonia fuel system 108.

[0061] It should be noted that the arrangement 100 may comprise both the evaporator 114 and the separator 116, or only one of the evaporator 114 and the separator 116.

[0062] The arrangement 100 may comprise a liquid ammonia inlet 141. The liquid ammonia inlet 141 may be connected to the fuel piping 133 via a liquid ammonia piping 143. The liquid ammonia inlet 141 may be configured to supply liquid ammonia from the evaporator 114 and/or the separator 116 to the fuel piping 133 such that the liquid ammonia may be mixed with the fuel arranged in the fuel piping 133. Thus, the liquid ammonia may be supplied to the burner 104 as a mixture with the fuel.

[0063] The arrangement 100 may comprise a combustion fan 120. The combustion fan 120 may be configured to provide air to the burner 104 for combustion of the

ammonia. The combustion fan 120 may be configured to supply a specific amount of air, based on pre-set requirements. The combustion fan 120 may further or alternatively be configured to direct the purge gas to the burner 104. The combustion fan may further or alternatively be configured to direct the purge gas to the burner. The combustion fan 120 may comprise the purge gas inlet 121, wherein the combustion fan 120 may be configured to mix the purge gas with combustion air. The combustion fan 120 may further be arranged to direct the mixture of purge gas and combustion air to the burner 104. The person skilled in the art realizes that the present disclosure by no means is limited to the preferred embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims.

Claims

1. An arrangement (100) for combusting purge gas originating from an ammonia fuel system (108) fueling an ammonia fueled engine (112), the arrangement (100) comprising:

a boiler system (102) comprising

a burner (104),
a fuel inlet (111) configured to supply a fuel and thereby sustain a support flame in the burner (104), and
a purge gas inlet (121) being configured to intermittently receive purge gas from the ammonia fuel system (108) and supply the purge gas to the burner (104), the purge gas comprising a mixture of ammonia and inert gas,

wherein the burner (104) is configured to combust the ammonia with the support flame,
wherein the arrangement (100) comprises the ammonia fuel system (108),
and wherein the ammonia fuel system (108) comprises

an ammonia fuel source (155) for storing ammonia,
a fuel supply system (110),
the ammonia fueled engine (112), and
a purge source (165) which contains the inert gas, and which is configured to purge ammonia from the ammonia fuel system (108) to the purge gas inlet (121) by flushing the inert gas through the ammonia fuel system (108).

2. The arrangement (100) according to claim 1, wherein the boiler system (102) is configured to operate in

one of at least a first mode (201) and a second mode (211), wherein

the first mode (201) is a heat production mode in which heat is produced, and
the second mode (211) is an ammonia safety purge mode in which a boiler (106) is kept warm and ready for fast operation and/or in which a pilot flame is sustained.

3. The arrangement (100) according to claim 2, wherein the boiler system (102) is configured to operate in one of at least a first sub-mode (201a) and a second sub-mode (201b) of the first mode (201), wherein, in the first sub-mode (201a), a main flame is sustained in the burner (104) for heat production and no purge gas is supplied to the burner (104), and, in the second sub-mode (201b), the main flame is sustained in the burner (104) for heat production and purge gas is supplied to the burner (104) and the ammonia is combusted with the main flame acting as the support flame.

4. The arrangement (100) according to claim 2 or 3, wherein the boiler system (102) is configured

to ignite a support flame by first igniting a pilot flame and then igniting the support flame from the pilot flame, or if a pilot flame is sustained directly ignite the support flame from the pilot flame, and
to supply purge gas to the burner (104) and combust the ammonia with the support flame.

5. The arrangement (100) according to any one of the preceding claims, wherein the fuel inlet (111) is connected via a fuel supply line (113, 133) to a fuel source (115, 135), the fuel source (115, 135) being configured to supply the fuel selected from the group consisting of liquefied natural gas (LNG), distillate and residual fuels.

6. The arrangement (100) according to any one of claims 1-5, wherein the mixture of ammonia and inert gas comprises gaseous ammonia, liquid ammonia, and inert gas.

7. The arrangement (100) according to claim 6, wherein the arrangement (100) further comprises an evaporator (114) configured to evaporate liquid ammonia into gaseous ammonia thereby providing a gaseous mixture of ammonia and inert gas to be supplied to the burner (104).

8. The arrangement (100) according to claim 6 or 7, wherein the arrangement (100) further comprises a separator (116) configured to separate the liquid ammonia from the gaseous ammonia and inert gas

thereby providing a gaseous mixture of ammonia and inert gas to be supplied to the burner (104).

9. The arrangement (100) according to any one of the preceding claims, wherein the burner (104) is a multi-fuel burner configured

to burn at least two different fuels, preferably two different liquid fuels, preferably one at the time, or
to burn one or more liquid fuels in combination with burning one or more gaseous fuels, wherein the one or more liquid fuels, preferably one liquid fuel at the time, is burnt simultaneously as the one or more gaseous fuels, preferably one gaseous fuel at the time, is burnt.

10. The arrangement (100) according to any one of the preceding claims, further comprising a combustion fan (120), the combustion fan (120) comprising the purge gas inlet (121), wherein the combustion fan (120) is configured to mix the purge gas with combustion air and to provide the mixture of purge gas and combustion air to the burner (104).

11. The arrangement (100) according to any one of the preceding claims, wherein the inert gas is nitrogen.

12. A method (200) for combusting purge gas originating from an ammonia fuel system (108) fueling an ammonia fueled engine (112), the method (200) comprising:

sustaining a support flame in a burner (104) comprised in a boiler system (102), wherein the support flame is sustained by a fuel supplied by a fuel inlet (111); and
intermittently supplying the purge gas, wherein the purge gas is supplied by a purge gas inlet (121) from the ammonia fuel system (108) to the burner (104), the purge gas comprising a mixture of ammonia and inert gas, and
combusting the ammonia in the burner (104) with the support flame.

13. The method (200) according to claim 12, wherein the boiler system (102) is configured to operate in one of at least a first mode (201) and a second mode (211), wherein

the first mode (201) is a heat production mode in which heat is produced, and
the second mode (211) is an ammonia safety purge mode in which the boiler is kept warm and ready for fast operation and/or in which a pilot flame is sustained.

Patentansprüche

1. Anordnung (100) zum Verbrennen von Spülgas, das aus einer Ammoniak-Brennstoffanlage (108) stammt, die einen ammoniakgetriebenen Motor (112) versorgt, wobei die Anordnung (100) Folgendes umfasst:

eine Kesselanlage (102), die Folgendes umfasst:

einen Brenner (104),
einen Brennstoffeinlass (111), der dafür konfiguriert ist, einen Brennstoff zuzuführen und dadurch eine Unterstützungsflamme in dem Brenner (104) aufrechtzuerhalten, und
einen Spülgaseinlass (121), der dafür konfiguriert ist, intermittierend Spülgas von der Ammoniak-Brennstoffanlage (108) zu erhalten und das Spülgas dem Brenner (104) zuzuführen, wobei das Spülgas ein Gemisch von Ammoniak und inertem Gas umfasst,
wobei der Brenner (104) dafür konfiguriert ist, das Ammoniak mit der Unterstützungsflamme zu verbrennen,
wobei die Anordnung (100) die Ammoniak-Brennstoffanlage (108) umfasst und wobei die Ammoniak-Brennstoffanlage (108) Folgendes umfasst:

eine Ammoniak-Brennstoffquelle (155) zum Speichern von Ammoniak,
eine Brennstoff-Zufuhranlage (110),
den ammoniakgetriebenen Motor (112) und
eine Spülquelle (165), die das inerte Gas enthält und die dafür konfiguriert ist, durch Strömenlassen des inertes Gases durch die Ammoniak-Brennstoffanlage (108) Ammoniak von der Ammoniak-Brennstoffanlage (108) zu dem Spülgaseinlass (121) zu spülen.

2. Anordnung (100) nach Anspruch 1, wobei die Kesselanlage (102) dafür konfiguriert ist, in einem von mindestens einem ersten Modus (201) und einem zweiten Modus (211) zu arbeiten, wobei

der erste Modus (201) ein Wärmeerzeugungsmodus ist, in dem Wärme erzeugt wird, und
der zweite Modus (211) ein Ammoniak-Sicherheitsspülmodus ist, in dem ein Kessel (106) für schnellen Betrieb warm- und bereitgehalten wird und/oder in dem eine Zündflamme aufrechterhalten wird.

3. Anordnung (100) nach Anspruch 2, wobei die Kesselanlage (102) dafür konfiguriert ist, in einem von mindestens einem ersten Untermodus (201a) und einem zweiten Untermodus (201b) des ersten Modus (201) zu arbeiten, wobei, in dem ersten Unter-

modus (201a), eine Hauptflamme in dem Brenner (104) zur Wärmeerzeugung aufrechterhalten wird und dem Brenner (104) kein Spülgas zugeführt wird und, in dem zweiten Untermodus (201b), die Hauptflamme in dem Brenner (104) zur Wärmeerzeugung aufrechterhalten wird und dem Brenner (104) Spülgas zugeführt wird und das Ammoniak mit der Hauptflamme verbrannt wird, die als die Unterstützungsflamme wirkt.

4. Anordnung (100) nach Anspruch 2 oder 3, wobei die Kesselanlage (102) dafür konfiguriert ist,

eine Unterstützungsflamme zu zünden durch zuerst Zünden einer Zündflamme und danach Zünden der Unterstützungsflamme von der Zündflamme oder, falls eine Zündflamme aufrechterhalten wird, unmittelbar die Unterstützungsflamme von der Zündflamme zu zünden, und dem Brenner (104) Spülgas zuzuführen und das Ammoniak mit der Unterstützungsflamme zu verbrennen.

5. Anordnung (100) nach einem der vorhergehenden Ansprüche, wobei der Brennstoffeinlass (111) über eine Brennstoff-Zufuhrleitung (113, 133) mit einer Brennstoffquelle (115, 135) verbunden ist, wobei die Brennstoffquelle (115, 135) dafür konfiguriert ist, den Brennstoff zuzuführen, der ausgewählt ist aus der Gruppe, die aus verflüssigtem Erdgas (LNG), Destillat und Restbrennstoffen besteht.

6. Anordnung (100) nach einem der Ansprüche 1 bis 5, wobei das Gemisch von Ammoniak und inertem Gas gasförmiges Ammoniak, flüssiges Ammoniak und inertes Gas umfasst.

7. Anordnung (100) nach Anspruch 6, wobei die Anordnung (100) ferner einen Verdampfer (114) umfasst, der dafür konfiguriert ist, flüssiges Ammoniak zu gasförmigem Ammoniak zu verdampfen, wodurch ein gasförmiges Gemisch von Ammoniak und inertem Gas bereitgestellt wird, das dem Brenner (104) zugeführt werden soll.

8. Anordnung (100) nach Anspruch 6 oder 7, wobei die Anordnung (100) ferner einen Abscheider (116) umfasst, der dafür konfiguriert ist, das flüssige Ammoniak von dem gasförmigen Ammoniak und dem inertem Gas abzuscheiden, wodurch ein gasförmiges Gemisch von Ammoniak und inertem Gas bereitgestellt wird, das dem Brenner (104) zugeführt werden soll.

9. Anordnung (100) nach einem der vorhergehenden Ansprüche, wobei der Brenner (104) ein Mehrbrennstoff-Brenner ist, der dafür konfiguriert ist,

mindestens zwei unterschiedliche Brennstoffe, vorzugsweise zwei unterschiedliche flüssige Brennstoffe, vorzugsweise einen nach dem anderen, zu verbrennen, oder

einen oder mehrere flüssige Brennstoffe in Kombination mit dem Verbrennen von einem oder mehreren gasförmigen Brennstoffen zu verbrennen, wobei der eine oder die mehreren flüssigen Brennstoffe, vorzugsweise ein flüssiger Brennstoff nach dem anderen, gleichzeitig zur Verbrennung des einen oder der mehreren gasförmigen Brennstoffe, vorzugsweise ein gasförmiger Brennstoff nach dem anderen.

10. Anordnung (100) nach einem der vorhergehenden Ansprüche, die ferner ein Verbrennungsgebläse (120) umfasst, wobei das Verbrennungsgebläse (120) den Spülgaseinlass (121) umfasst, wobei das Verbrennungsgebläse (120) dafür konfiguriert ist, das Spülgas mit Verbrennungsluft zu mischen und das Gemisch von Spülgas und Verbrennungsluft an den Brenner (104) zu liefern.

11. Anordnung (100) nach einem der vorhergehenden Ansprüche, wobei das inerte Gas Stickstoff ist.

12. Verfahren (200) zum Verbrennen von Spülgas, das aus einer Ammoniak-Brennstoffanlage (108) stammt, die einen ammoniakgetriebenen Motor (112) mit Brennstoff versorgt, wobei das Verfahren (200) Folgendes umfasst:

Aufrechterhalten einer Unterstützungsflamme in einem Brenner (104), der in einer Kesselanlage (102) umfasst ist, wobei die Unterstützungsflamme durch einen Brennstoff aufrechterhalten wird, der durch einen Brennstoffeinlass (111) zugeführt wird, und intermittierendes Zuführen des Spülgases, wobei das Spülgas durch einen Spülgaseinlass (121) von der Ammoniak-Brennstoffanlage (108) dem Brenner (104) zugeführt wird, wobei das Spülgas ein Gemisch von Ammoniak und inertem Gas umfasst, und Verbrennen des Ammoniaks in dem Brenner (104) mit der Unterstützungsflamme.

13. Verfahren (200) nach Anspruch 12, wobei die Kesselanlage (102) dafür konfiguriert ist, in einem von mindestens einem ersten Modus (201) und einem zweiten Modus (211) zu arbeiten, wobei

der erste Modus (201) ein Wärmeerzeugungsmodus ist, in dem Wärme erzeugt wird und der zweite Modus (211) ein Ammoniak-Sicherheitsspülmodus ist, in dem der Kessel für schnellen Betrieb warm- und bereitgehalten wird und/oder in dem eine Zündflamme auf-

rechterhalten wird.

Revendications

1. Agencement (100) permettant de brûler un gaz de purge provenant d'un système de combustible ammoniac (108) ravitaillant un moteur alimenté à l'ammoniac (112), l'agencement (100) comprenant :
un système de chaudière (102) comprenant :

un brûleur (104),
une entrée de combustible (111) configurée pour fournir un combustible et maintenir ainsi une flamme de support dans le brûleur (104), et une entrée de gaz de purge (121) étant configurée pour recevoir par intermittence un gaz de purge du système de combustible d'ammoniac (108) et fournir le gaz de purge au brûleur (104), le gaz de purge comprenant un mélange d'ammoniac et de gaz inerte,
dans lequel le brûleur (104) est configuré pour brûler l'ammoniac avec la flamme de support, dans lequel l'agencement (100) comprend le système de combustible d'ammoniac (108),
et dans lequel le système de combustible ammoniac (108) comprend :

une source de combustible ammoniac (155) permettant de stocker de l'ammoniac,
un système d'alimentation de combustible (110),
le moteur alimenté à l'ammoniac (112), et une source de purge (165) qui contient le gaz inerte, et qui est configurée pour purger de l'ammoniac du système de combustible ammoniac (108) à l'entrée de gaz de purge (121) en faisant s'écouler le gaz inerte à travers le système de combustible ammoniac (108).

2. Agencement (100) selon la revendication 1, dans lequel le système de chaudière (102) est configuré pour fonctionner dans l'un d'au moins un premier mode (201) et un deuxième mode (211), dans lequel

le premier mode (201) est un mode de production de chaleur dans lequel de la chaleur est produite, et
le deuxième mode (211) est un mode de purge de sécurité d'ammoniac dans lequel une chaudière (106) est maintenue chaude et prête à un fonctionnement rapide et/ou dans lequel une flamme pilote est entretenue.

3. Agencement (100) selon la revendication 2, dans lequel le système de chaudière (102) est configuré pour fonctionner dans l'un d'au moins un premier

sous-mode (201a) et un deuxième sous-mode (201b) du premier mode (201), dans lequel, dans le premier sous-mode (201a), une flamme principale est maintenue dans le brûleur (104) pour la production de chaleur et aucun gaz de purge n'est fourni au brûleur (104), et, dans le deuxième sous-mode (201b), la flamme principale est maintenue dans le brûleur (104) pour la production de chaleur et un gaz de purge est fourni au brûleur (104) et l'ammoniac est brûlé avec la flamme principale agissant comme flamme de support.

4. Agencement (100) selon les revendications 2 ou 3, dans lequel le système de chaudière (102) est configuré :

pour allumer une flamme de support en allumant d'abord une flamme pilote, et en allumant ensuite la flamme de support à partir de la flamme pilote, ou, si une flamme pilote est maintenue, pour allumer directement la flamme de support à partir de la flamme pilote, et
pour fournir un gaz de purge au brûleur (104) et brûler l'ammoniac avec la flamme de support.

5. Agencement (100) selon l'une quelconque des revendications précédentes, dans lequel l'entrée de combustible (111) est connectée *via* une conduite d'alimentation de combustible (113, 133) à une source de combustible (115, 135), la source de combustible (115, 135) étant configurée pour fournir le combustible sélectionné dans le groupe constitué de gaz naturel liquéfié (GNL), de distillat et de combustibles résiduels.

6. Agencement (100) selon l'une quelconque des revendications 1 à 5, dans lequel le mélange d'ammoniac et de gaz inerte comprend de l'ammoniac gazeux, de l'ammoniac liquide et un gaz inerte.

7. Agencement (100) selon la revendication 6, dans lequel l'agencement (100) comprend en outre un évaporateur (114) configuré pour faire s'évaporer de l'ammoniac liquide en ammoniac gazeux, fournissant ainsi un mélange gazeux d'ammoniac et de gaz inerte à fournir au brûleur (104).

8. Agencement (100) selon les revendications 6 ou 7, dans lequel l'agencement (100) comprend en outre un séparateur (116) configuré pour séparer l'ammoniac liquide de l'ammoniac gazeux et du gaz inerte, fournissant ainsi un mélange gazeux d'ammoniac et de gaz inerte à fournir au brûleur (104).

9. Agencement (100) selon l'une quelconque des revendications précédentes, dans lequel le brûleur (104) est un brûleur multi-combustible configuré :

pour brûler au moins deux combustibles différents, de préférence deux combustibles liquide différents, de préférence un à la fois, ou pour brûler un ou plusieurs combustibles liquides en combinaison avec la combustion d'un ou plusieurs combustibles gazeux, dans lequel le ou les combustibles liquides, de préférence un combustible liquide à la fois, sont brûlés simultanément au brûlage des un ou plusieurs combustibles gazeux, de préférence un combustible gazeux à la fois.

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10. Agencement (100) selon l'une quelconque des revendications précédentes, comprenant en outre un ventilateur de combustion (120), le ventilateur de combustion (120) comprenant l'entrée de gaz de purge (121), dans lequel le ventilateur de combustion (120) est configuré pour mélanger le gaz de purge avec de l'air de combustion et pour fournir le mélange de gaz de purge et d'air de combustion au brûleur (104).
11. Agencement (100) selon l'une quelconque des revendications précédentes, dans lequel le gaz inerte est de l'azote.
12. Procédé (200) permettant de brûler un gaz de purge provenant d'un système de combustible ammoniac (108) alimentant un moteur alimenté à l'ammoniac (112), le procédé (200) comprenant :
 - le soutien d'une flamme de support dans un brûleur (104) compris dans un système de chaudière (102), dans lequel la flamme de support est soutenue par un combustible fourni par une entrée de combustible (111) ; et
 - la fourniture par intermittence du gaz de purge, dans lequel le gaz de purge est fourni par une entrée de gaz de purge (121) du système de combustible d'ammoniac (108) au brûleur (104), le gaz de purge comprenant un mélange d'ammoniac et de gaz inerte, et
 - la combustion de l'ammoniac dans le brûleur (104) avec la flamme de support.
13. Procédé (200) selon la revendication 12, dans lequel le système de chaudière (102) est configuré pour fonctionner dans l'un d'au moins un premier mode (201) et un deuxième mode (211), dans lequel
 - le premier mode (201) est un mode de production de chaleur dans lequel de la chaleur est produite, et
 - le deuxième mode (211) est un mode purge de sécurité d'ammoniac dans lequel la chaudière est maintenue chaude et prête à un fonctionnement rapide et/ou dans lequel une flamme pilote est maintenue.

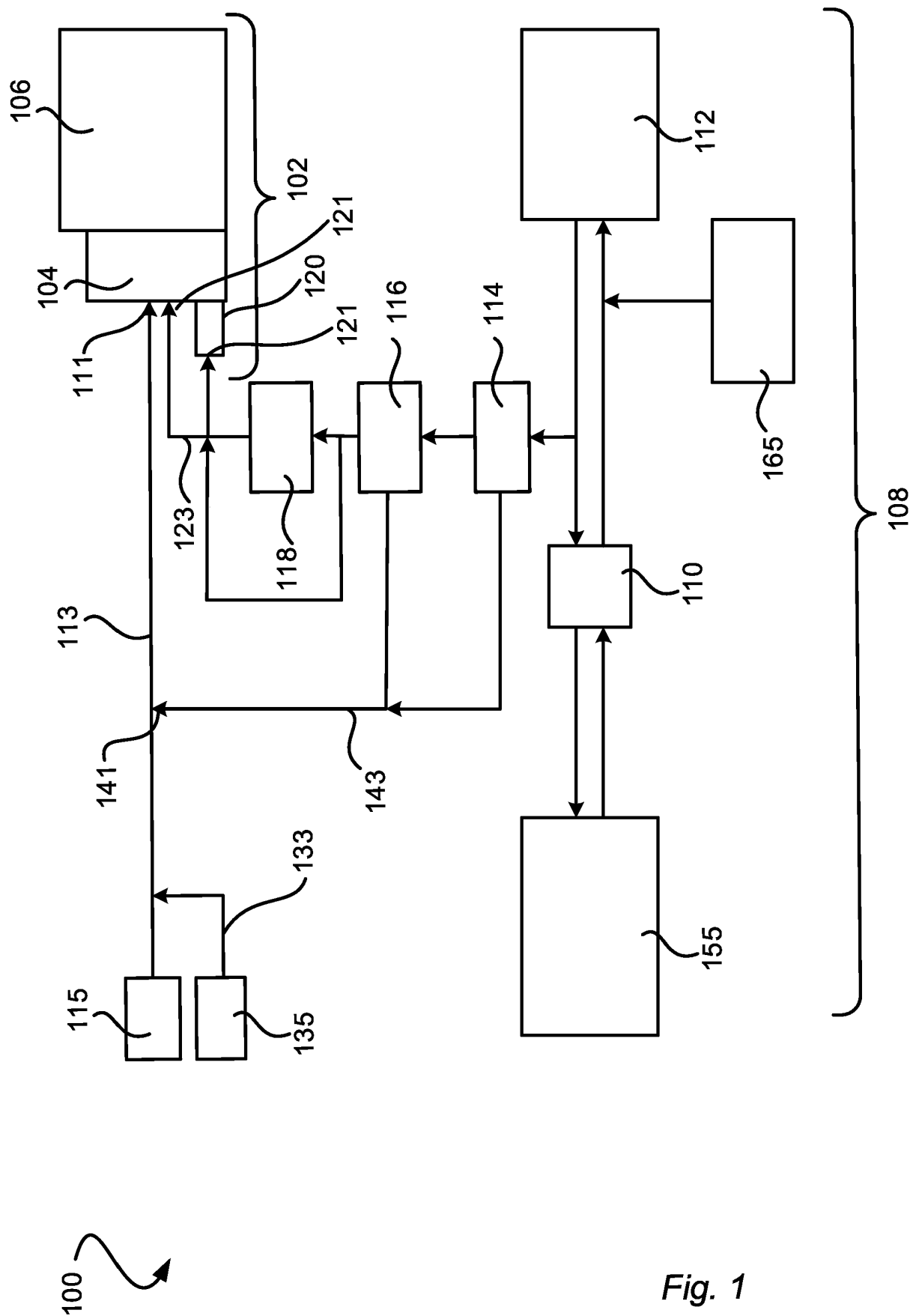


Fig. 1

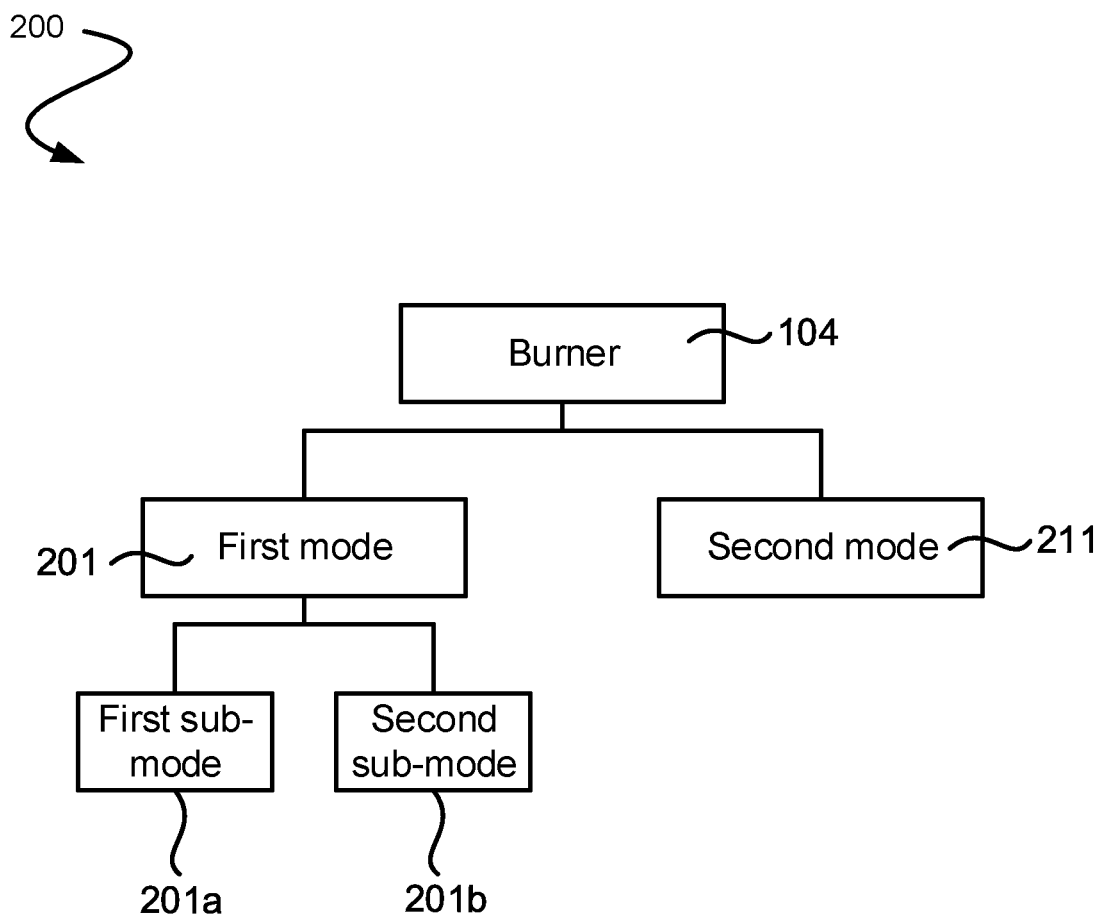


Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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