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(54) **CONTROL MECHANISM FOR A COMBUSTION APPLIANCE**

(57) Control mechanism (1) for a combustion appliance (2), in particular a gas boiler, the combustion appliance (2) having a fuel gas supply line (3), the control mechanism comprising a gas sensor (4) placeable in the fuel gas supply line (3) for measuring a physical characteristic of a gas flowing in the fuel gas supply line (3), and a control unit (5) to control the operation of the combustion appliance (2), the control unit (5) being connected to the gas sensor (4) to acquire sensor data from the gas sensor (4), wherein the control unit (5) is configured to control the operation of the combustion appliance (2) after determining the gas type flowing in the fuel gas supply line (3) based on sensor data.

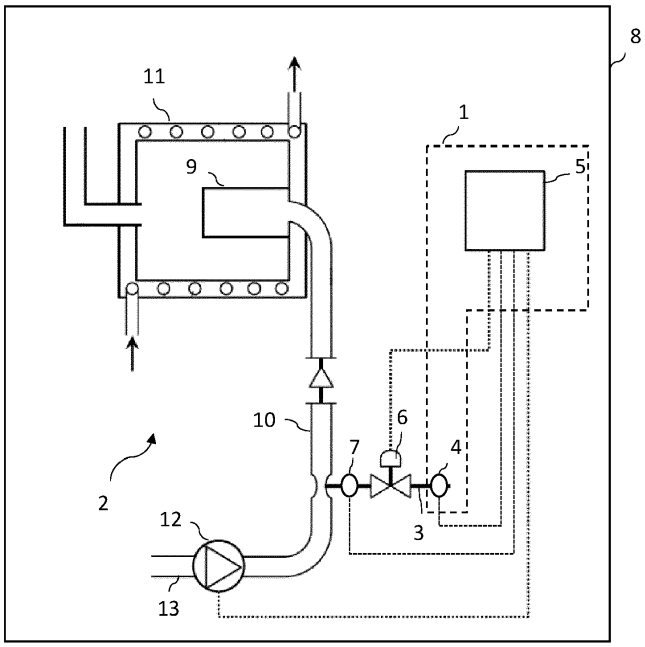

FIG. 1

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Description

[0001] The invention relates to a control mechanism for a combustion appliance, in particular a gas boiler, and a method for controlling the operation of said combustion appliance. Additionally, the invention relates to a heating system and a use of said control mechanism. The invention also relates to a computer program product executing the method.

[0002] Combustion appliance such as gas boilers combust combustion gas to heat water for domestic use and/or central heating system facilities in buildings. The boilers can be used to operate in different modes during their functioning. However, the process steps of each operating mode can vary based on the characteristics of the gas boiler. In particular, control units are used to control the operation of the combustion appliances based on setting parameters associated to the gas type used for the combustion. It is noted that the process steps of the operating mode can be adjusted or different control procedures can be taken into account, if a different combustion gas is used for the combustion. For example, some factors can count differently on the boiler's efficiency, if the combustion gas comprises pure hydrogen or pure hydrocarbons.

[0003] It is known the employment of dedicated gas sensors to determine the gas type used in a combustion appliance. Document DE 102018105185 A1 describes for example a method for detecting fuel gas in a fuel gas operated heater. In particular, the document discloses a method for fuel gas specimen detection when starting a fuel gas powered heating device with electronic gas air composite using a gas mass sensor for determining the fuel gas type before the start of the burner. The method according to this prior art document can detect the gas type and adjust some parameters, such as related to the gas flowing, based on the gas type. In particular, the method makes it possible to determine the type of fuel gas before the burner is ignited and to limit the fuel gas-air mixture required for the start to a smaller range in order to obtain an optimum combustible gas/air mixture for starting the burner. However, in case of using natural gas or hydrogen as fuel gas, it could be very risky not knowing exactly in advance which fuel gas is flowing in the appliance when igniting the boiler. As a matter of fact, natural gas and/or propane requires different parameter settings and another burner compared to hydrogen.

[0004] It is also known the use of different sensors to detect the presence of fuel gases mainly containing hydrogen, mainly containing hydrocarbons or containing a mixture of both.

[0005] However, the hydrogen detection is usually based on absence of ionization signal. In this case the boiler did already try to ignite, which could lead to flashback or explosion in case of wrong burner installed or wrong parameter settings.

[0006] It is therefore an object to provide a mechanism for controlling the operation of a combustion appliance based on the gas type used for the combustion that is able to prevent ignition in case of wrong parameter settings. In particular, it is desirable to provide a control mechanism that is more efficient in detecting the type of fuel gas used for combustion and controlling the operation of the combustion appliance accordingly.

[0007] The object is solved by a control mechanism for a combustion appliance, in particular a gas boiler, the combustion appliance having a fuel gas supply line, the control mechanism comprising:

> a gas sensor placeable in the fuel gas supply line for measuring a physical characteristic of a gas flowing in the fuel gas supply line; and
> a control unit to control the operation of the combustion appliance, the control unit being connected to the gas sensor to acquire sensor data from the gas sensor,
> wherein the control unit is configured to control the operation of the combustion appliance after determining the gas type flowing in the fuel gas supply line based on sensor data.

[0008] Based on the fact that the gas sensor is placeable in the fuel gas supply line, the gas detection can be carried out earlier, before the fuel gas is mixed with air, thereby making the mechanism safer compared to the solution actually present in prior art. In this way, it is possible to avoid risky situations during the ignition phase, especially in case it is not known in advance if the fuel gas is natural gas or hydrogen.

[0009] In one example, the control unit is configured to control the operation of the combustion appliance based on setting parameters associated to the fuel gas type and to prevent the operation of the combustion appliance based on said setting parameters if the gas type determined to be flowing in the fuel gas supply line is different from the fuel gas type associated to the setting parameters. The controller comprises specific setting parameters associated to the gas type the boiler is combusting, i.e., the fuel gas. In case the setting parameters do not match with the measured fuel gas type by the sensor, the boiler is prevented from being operated using these wrong setting parameters. Eventually, an inspection of a service personnel can be requested. In this way, it is possible to avoid using wrong parameters and consequently attempting an ignition in unsafe conditions.

[0010] According to another example, the control unit is configured to block the operation of the combustion appliance and/or to modify the setting parameters if the gas type determined to be flowing in the fuel gas supply line is different from the fuel gas type associated to the setting parameters. Advantageously, in case of an electronic gas air system, the setting parameters can be adjusted based on the gas type measured, and the boiler can safely operate further.

[0011] The physical characteristic of the gas measured by the gas sensor can be advantageously the thermal

conductivity. As a matter of fact, the thermal conductivity of hydrogen is about six times higher compared to that of methane; therefore it can be easily detected by a dedicated sensor. In this way, it is possible to detect the difference between natural gas (can be with 20-30% H2) or propane/butane/LPG with pure hydrogen (or at least more than 80% H2) as fuel gas using a single gas sensor. Accordingly, the gas sensor can be a thermal conductivity detector, TCD, or a microthermal gas sensor.

[0012] In a further example, the gas sensor is placeable upstream or downstream a gas valve, the gas valve being placeable in the fuel gas supply line of the combustion appliance. Alternatively, the gas sensor is placeable upstream the gas valve and an additional gas sensor is placeable downstream the gas valve. The additional gas sensor can be placed in the fuel gas supply line of the combustion appliance. Advantageously, the gas valve together with the gas sensor and/or the additional gas sensor can be connected to the control unit in order to immediately regulate the fuel gas flow, e.g. closing the valve, based on the sensor data. The gas sensor can be particularly placed at a gas meter.

[0013] Depending on the thermal conductivity of the fuel gas, the gas sensor - as well as the additional gas sensor - is able to distinguish between natural gas, propane/butane and pure hydrogen. Pure hydrogen is present when the fuel gas has more than 95 mol% hydrogen. According to an example, the gas sensor is configured to detect in the gas supply line at least one of:

- natural gas;
- propane;
- butane; and
- hydrogen with a concentration that is higher than 20mol%, in particular at least 98mol%.

[0014] According to an aspect of the present invention, a heating system with a combustion appliance and an inventive control mechanism is provided.

[0015] According to an example, the combustion appliance comprises at least a burner for the combustion of a fuel gas, a gas mixture channel for guiding an air/fuel gas mixture to the burner, and a gas supply line for inserting fuel gas in the gas mixture channel, wherein the gas sensor of the control mechanism is located in the gas supply line.

[0016] In an additional example, the system further comprises:
a gas valve located in the gas supply line to regulate the fuel gas flow, wherein the gas sensor is placed upstream or downstream said gas valve. Alternatively the gas sensor is placed upstream said gas valve and an additional gas sensor is present. Said additional gas sensor is placed downstream said gas valve located in the gas supply line to regulate the fuel gas flow.

[0017] In a further aspect, the use of the inventive mechanism for controlling the operation of a combustion appliance, in particular of a gas boiler, is provided.

[0018] In another aspect, a method for controlling the operation of a combustion appliance, in particular a gas boiler, is provided. the method comprises:

measuring a physical characteristic of a gas flowing in a fuel gas supply line of the combustion appliance by a gas sensor placeable in the fuel gas supply line and acquiring sensor data;
determining the gas type flowing in the fuel gas supply line based on the sensor data by a control unit connected to the gas sensor; and
controlling the operation of the combustion appliance based on said determination.

[0019] In an additional aspect, the method comprises controlling the operation of the combustion appliance based on setting parameters associated to the fuel gas type and preventing the operation of the combustion appliance based on said setting parameters if the gas type determined to be flowing in the fuel gas supply line is different from the fuel gas type associated to the setting parameters. Additionally or alternatively, the method comprises blocking the operation of the combustion appliance and/or modifying the setting parameters if the gas type determined to be flowing in the gas supply line is different from the fuel gas type associated to the setting parameters.

[0020] According to another example, the method further comprises generating an alarm message if the gas type determined by the gas sensor is different from the fuel gas type associated to the setting parameters.

[0021] In one aspect, a computer program product is provided, the computer program product comprising instructions which, when the program is executed by a computer or by the control unit, cause the computer or the control unit to carry out the inventive method. Furthermore, a data carrier is provided on which the computer program is stored and/or data carrier signal is provided which transmits the computer program.

[0022] 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 the heating system including the control mechanism according to one example.

Figure 2 shows a flow chart of an inventive method according to an example.

[0023] Figure 1 illustrates a heating system 8 comprising a combustion appliance 2 such as gas boiler used for the combustion of fuel gas, for example containing hydrocarbons and/or hydrogen. The fuel gas is mixed with air and is provided to the burner 9 through a gas mixture channel 10, the burner 9 being coupled to a heat exchanger 11 for heating water for domestic use and/or

central heating system facilities in buildings. The gas mixture channel 10 receives air from an air supply line 13 and fuel gas from a gas supply line 3. The flow of air - and correspondingly the flow of the air/fuel gas mixture - can be regulated by a fan element 12 located in the air supply line 13. Advantageously, the fan element 12 is located upstream the region where the fuel gas is inserted into the gas mixture channel 10.

[0024] The heating system 8 comprises furthermore a control mechanism 1 including a control unit 5 and a gas sensor 4. The gas sensor 4 is located in the gas supply line 3 and serves to measure the thermal conductivity of the gas flowing in the gas supply line 3. The data acquired by the gas sensor 4 are analyzed by the control unit 5 in order to determine the gas type flowing in the gas supply line 3 and to compare the characteristics of the fuel gas with the setting parameters used for controlling the combustion appliance 2. For example, the combustion appliance 2 is a gas boiler using methane as fuel gas and the operating parameters are set to provide the optimal combustion for methane.

[0025] The gas sensor 4 measures a thermal conductivity and the control unit 5 can determine the type of fuel gas actually flowing in the fuel gas supply line 3. For example, the ratio between the thermal conductivity of methane and the thermal conductivity of air at 100 °C is about 1.5. If the control unit, based on the gas sensor's 4 measurements, determines that the ratio is 1.5, no changes in the operation of the combustion appliance 2 are provided. On the other hand, in case the ratio is different (lower or higher), the control unit 5 is configured to prevent the operation of the combustion appliance 2 using the predefined setting parameters. In particular, the setting parameters can be modified and adapted to the gas type flowing in the fuel gas supply line 3, or the operation of the combustion appliance 2 can be blocked (for example interrupting the fuel gas supply) to avoid risky situations. For example, if the above-mentioned ratio is about 1.021 at 100 °C, the control unit 5 would determine that the fuel gas flowing in the gas supply line 3 is not methane but rather propane.

[0026] Accordingly, the operation of the combustion appliance 2 can be adapted to the combustion of propane and suitable setting parameters can be selected. On the other hand, if the above-mentioned ratio is much higher than that set in advance, i.e. about 6.918 at 100 °C, the control unit 5 would determine that the fuel gas flowing in the fuel gas supply line 3 is not methane but rather hydrogen. Accordingly, the operation can be blocked in order to avoid the ignition in the burner 9.

[0027] It is noted that using hydrogen as fuel gas would require not only different setting parameters but also a different burner 9 configuration. For this purpose, the control unit 5 is connected to the fan element 12 to regulate and eventually adapt the air to fuel gas ratio. Also, the control unit 5 can be directly connected to an additional gas sensor 7 located in the fuel gas supply line 3 to regulate the fuel gas flow and eventually prevent the supply of the fuel gas in the gas mixture channel 10. As shown in figure 1, the gas sensor 4 can be placed upstream a gas valve 6 located at the region where the fuel gas supply line 3 is connected to the gas mixture channel 10.Downstream the gas valve 6 can be placed the additional gas sensor 7.

[0028] In a non shown embodiment only a gas sensor, in particular the gas sensor 4 arranged upstream the gas valve 6 can be provided. A single gas sensor, can be sufficient to avoid supplying a wrong fuel gas into the gas mixture channel 10. With the term "wrong fuel gas" is intended a fuel gas that is different from the fuel gas type for which the operation parameters of the combustion appliance 2 are set and for which an ignition (or an attempt of ignition) of the burner 9 would cause a risky situation, e.g., an explosion or a strong damage of the components of the combustion appliance 2.

[0029] Figure 2 shows a flow chart of the method 100 for controlling the operation of a combustion appliance 2 and in particular for operating a gas boiler 2 using the control mechanism 1 as described above.

[0030] At step S101, the gas sensor 4 measures the thermal conductivity of the gas flowing in the fuel gas supply line 3. Accordingly, sensor data are acquired.

[0031] At step S102, the control unit 5 determines the gas type flowing in the fuel gas supply line 3. Based on the sensor data, the control unit 5 can for example determine the gas type as a consequence of a calculation of the ratio between the thermal conductivity of the fuel gas at a certain temperature and the thermal conductivity of a reference gas, such as air. Advantageously, the control mechanism 1 can be provided with a temperature sensor and/or a pressure sensor and/or a humidity sensor.

[0032] Based on the determination of the gas type flowing in the fuel gas supply line 3, the control unit 5 can control the operation of the combustion appliance 2 (step S103).

[0033] As mentioned above, the operation of the combustion appliance 2 depends on the setting parameters associated to the fuel gas type. Therefore, the control of the operation of the combustion appliance 2 can be carried out by preventing the operation of the combustion appliance based on said setting parameters if the gas type determined to be flowing in the fuel gas supply line is different from the fuel gas type associated to the setting parameters (step S104). In this way, it is possible to avoid an attempt of ignition of the burner 9 using setting parameters or boiler's configuration that are not suitable for the fuel gas type.

[0034] In particular, at step S105 the operation of the combustion appliance 2 can be blocked if the gas type determined to be flowing in the gas supply line ~~(~~3~~)~~ is different from the fuel gas type associated to the setting parameters. Alternatively or additionally, at step S106, the setting parameters can be modified (i.e., adapted to the different fuel gas type) if the gas type determined to be flowing in the gas supply line (3) is different from the

fuel gas type associated to the setting parameters. This modification or adaptation of the setting parameters can occur manually or automatically.

[0035] In order to increase the safety, at step S107, an alarm message can be generated if the gas type determined by the gas sensor ~~(4)~~ is different from the fuel gas type associated to the setting parameters. The message can be displayed on a screen provided on the combustion appliance 2 or the heating system 8 and/or can be directly sent to a separated device (for example an external computer or a personal mobile device of a user). In this way, a dedicated personnel can be notified that the type of gas flowing in the fuel gas line 3 is different from the gas type associated to the operating setting parameters of the combustion appliance 2 and that a possible risky situation can occur. Advantageously, since the gas sensor 4 (and eventually the additional gas sensor 7) is located in the fuel gas line 3, the gas valve 6 can be promptly actuated (i.e., closed) to prevent the ignition phase of the combustion appliance 2 while waiting the intervention of the personnel.

Reference Signs

[0036]

1	Control mechanism
2	Combustion mechanism
3	Gas supply line
4	Gas sensor
5	Control unit
6	Gas valve
7	Additional gas sensor
8	Heating system
9	Burner
10	Gas mixture channel
11	Heat exchanger
12	Fan element
13	Air supply channel
100	Method

Claims

1. Control mechanism (1) for a combustion appliance (2), in particular a gas boiler, the combustion appliance (2) having a fuel gas supply line (3), the control mechanism comprising:

a gas sensor (4) placeable in the fuel gas supply line (3) for measuring a physical characteristic of a gas flowing in the fuel gas supply line (3); and
a control unit (5) to control the operation of the combustion appliance (2), the control unit (5) being connected to the gas sensor (4) to acquire sensor data from the gas sensor (4),
wherein the control unit (5) is configured to control the operation of the combustion appliance (2) after determining the gas type flowing in the fuel gas supply line (3) based on sensor data.

2. Control mechanism (1) according to claim 1, **characterized in that** the control unit (5) is configured to control the operation of the combustion appliance (2) based on setting parameters associated to the fuel gas type and to prevent the operation of the combustion appliance (2) based on said setting parameters if the gas type determined to be flowing in the fuel gas supply line (3) is different from the fuel gas type associated to the setting parameters.

3. Control mechanism (1) according to claim 2, **characterized in that** the control unit (5) is configured to block the operation of the combustion appliance (2) and/or to modify the setting parameters if the gas type determined to be flowing in the fuel gas supply line (3) is different from the fuel gas type associated to the setting parameters.

4. Control mechanism (1) according to any one of claims 1 to 2, **characterized in that** the gas sensor (4) is a thermal conductivity detector, TCD, or a microthermal gas sensor.

5. Control mechanism (1) according to any one of claims 1 to 3, **characterized in that**

a. the gas sensor (4) is placeable upstream or downstream a gas valve (6), the gas valve (6) being placeable in the fuel gas supply line (3) of the combustion appliance (1); or
b. the gas sensor (4) is placeable upstream a gas valve (6) and an additional gas sensor (7) is placeable downstream the gas valve (6), the gas sensor (4) and the additional gas sensor (7) being placeable in the fuel gas supply line (3) of the combustion appliance (1).

6. Control mechanism (1) according to claim 5, **characterized in that**

a. the gas valve (6) is a pneumatic controlled gas valve or an electronic controlled gas valve.

7. Control mechanism (1) according to any one of claims 1 to 6, **characterized in that** the gas sensor (4) is configured to detect in the gas supply line (3) at least one of:

a. natural gas;
b. propane;
c. butane; and
d. hydrogen with a concentration that is higher than 20mol%, in particular at least 98mol%.

8. Heating system (8) with a combustion appliance (2)

and a control mechanism (1) according to one of the claims 1 to 7.

9. Heating system (8) according to claim 8, **characterized in that** the combustion appliance (2) comprises at least a burner (9) for the combustion of a fuel gas, a gas mixture channel (10) for guiding an air/fuel gas mixture to the burner (9), and a gas supply line (3) for inserting fuel gas in the gas mixture channel (10), wherein the gas sensor (4) of the control mechanism (1) is located in the gas supply line (3).

10. Heating system (8) according to any one of claim 9, **characterized in that** the system (8) further comprises:

a. a gas valve (6) located in the gas supply line (3) to regulate the fuel gas flow, wherein the gas sensor (4) is placed upstream said gas valve (6); or
b. a gas valve (6) located in the gas supply line (3) to regulate the fuel gas flow, wherein the gas sensor (4) is placed upstream said gas valve (6) and an additional gas sensor (7) is placed downstream said gas valve (6).

11. Use of a control mechanism (1) according to any one of claims 1 to 7 for controlling the operation of a combustion appliance (2), in particular a gas boiler.

12. Method (100) for controlling the operation of a combustion appliance (2), in particular a gas boiler, the method comprising:

measuring (S101) a physical characteristic of a gas flowing in a fuel gas supply line (3) of the combustion appliance (2) by a gas sensor (4) placeable in the fuel gas supply line (3) and acquiring sensor data;
determining (S102) the gas type flowing in the fuel gas supply line (3) based on the sensor data by a control unit (5) connected to the gas sensor (4); and
controlling (S103) the operation of the combustion appliance (2) based on said determination.

13. Method (100) according to claim 12, **characterized in that** the method comprises:

a. controlling the operation of the combustion appliance (2) based on setting parameters associated to the fuel gas type and preventing (S104) the operation of the combustion appliance (2) based on said setting parameters if the gas type determined to be flowing in the fuel gas supply line (3) is different from the fuel gas type associated to the setting parameters; and/or
b. blocking (S105) the operation of the combustion appliance (2) and/or modifying (S106) the setting parameters if the gas type determined to be flowing in the gas supply line (3) is different from the fuel gas type associated to the setting parameters.

14. Method (100) according to any one of claims 12 to 13, **characterized in that** the method further comprises generating (S107) an alarm message if the gas type determined by the gas sensor (4) is different from the fuel gas type associated to the setting parameters.

15. Computer program product comprising instructions which, when the program is executed by a computer or control unit, cause the computer or the control unit to carry out the method according to one of the claims 12 to 14.

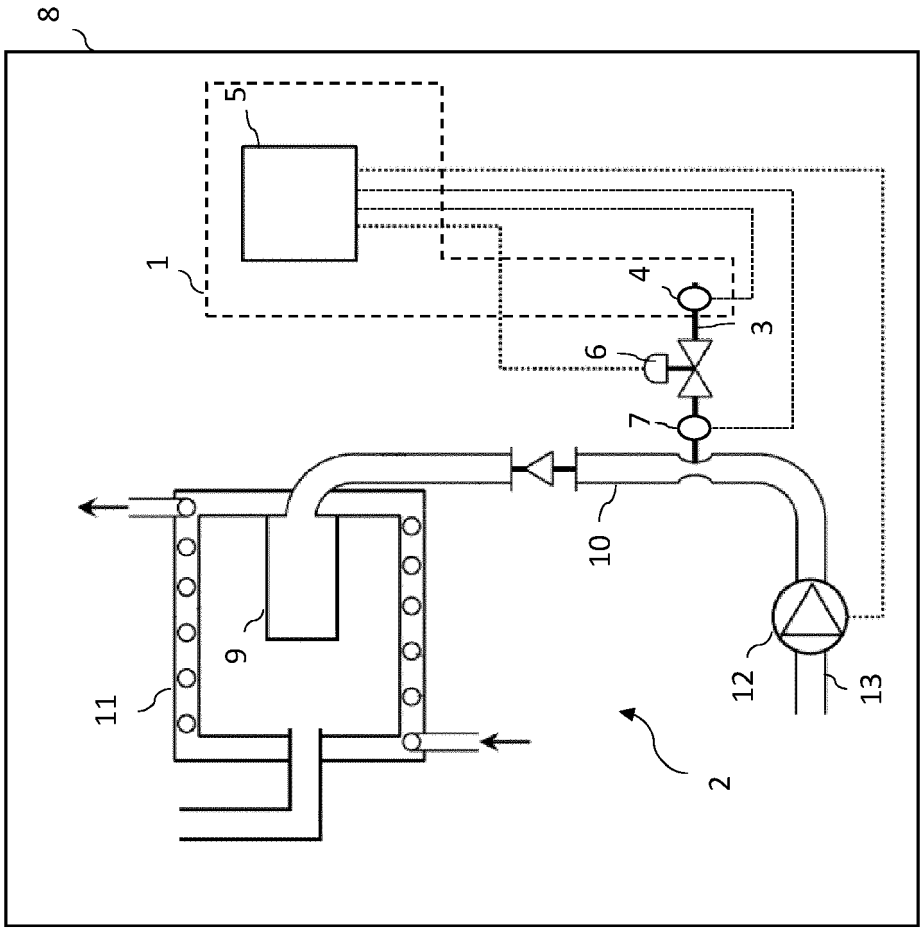

FIG. 1

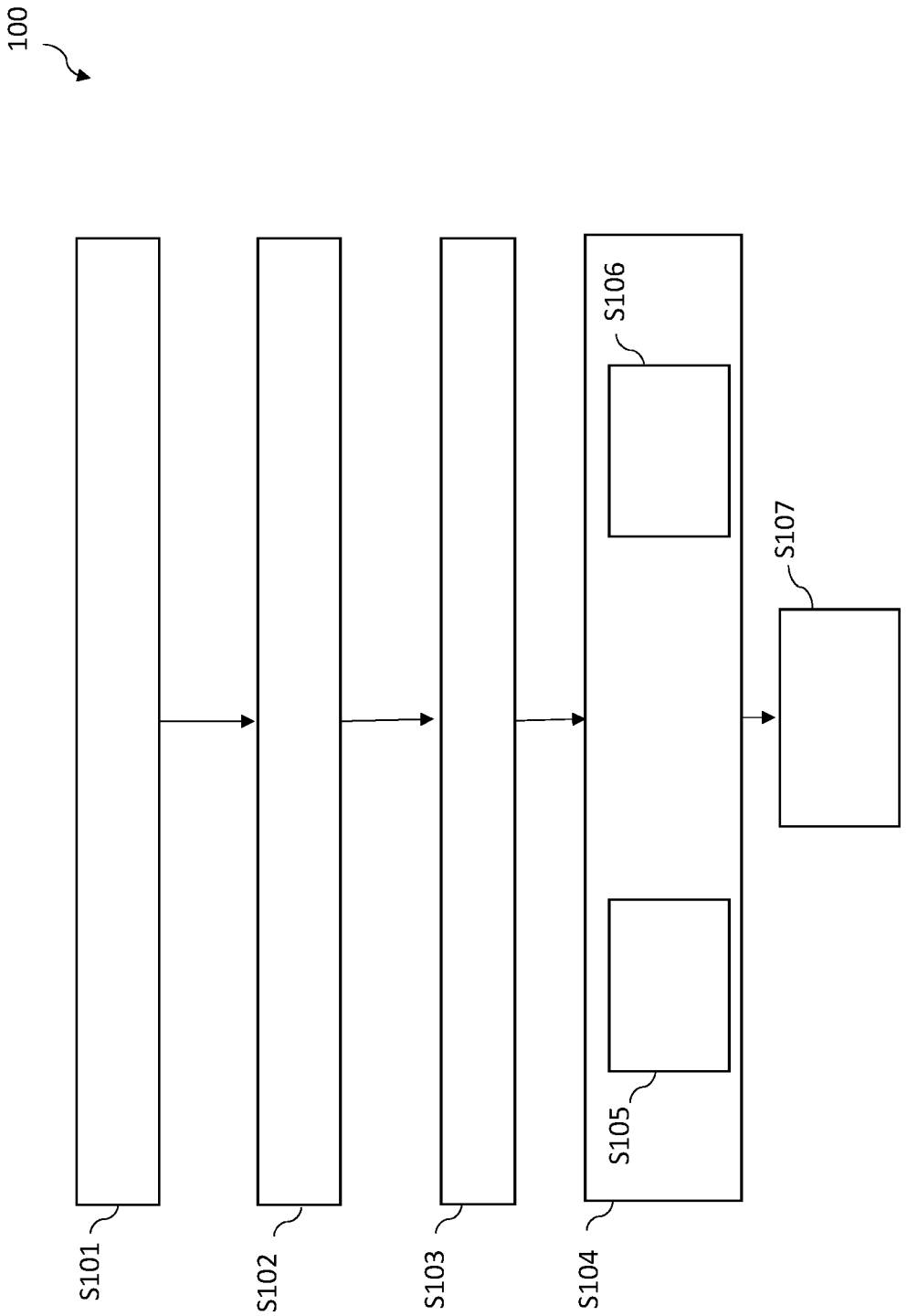

FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 9350

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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