

Description

[0001] The invention relates to a safety mechanism and a heating system with such a safety mechanism. Additionally, the invention relates to a method of operating a gas boiler and to a use of the safety mechanism for leakage detection in a boiler or in a heating system. In addition, the invention relates to a computer program product.

[0002] Gas boilers combust gas fuel to heat water for domestic use and/or central heating systems in buildings. Exhaust flue gas is generated by this combustion. Usually, a central heating water circuit is heated, as well as a hot water supply. A gas leak, both considering the combustible fuel gas or the exhaust flue gas, can be very dangerous. In fact, the gas can accumulate in closed spaces, such as the room containing the boiler or even the boiler's cabinet, and determine the conditions for an explosion. Several operating components of the gas boiler, such as the fan or the pump can trigger for an explosion. It is therefore desirable to detect a possible gas leak in a timely manner in order to prevent an explosion and specifically to detect the location of the gas leak. It is particularly desirable to avoid that the operating parts of the boiler can trigger an explosion in case of gas leak. It is furthermore desirable that the safety conditions of the gas boiler are continuously monitored.

[0003] EP 0 621 472 B1 is directed to a system to determine the leakage of water from a boiler wherein steam is generated in a boiler from feed-water fed to the boiler, and the concentration of impurities in the boiler water within the boiler is reduced by withdrawing fractions thereof as blowdown while admitting additional feed-water as boiler-water makeup. This document is also directed to a method for determining the leakage comprising employing as the inert component an inert tracer, sensing a characteristic of the inert tracer in the boiler at steady state equivalent to its concentration in the boiler water, converting the sensed characteristic to a value equivalent to the concentration of the inert tracer in the boiler water, and activation of a signal when a variance in the cyclic concentration fluctuation of said inert tracer occurs that is consistent with a leakage of boiler water.

[0004] EP 0 976 989 B1 is directed to a water circuit for a combined service wall-mounted gas-fired boiler including a primary circuit in which the hot water for room heating is circulated and a secondary circuit in which hot water for domestic use is circulated. In order to fill with water the primary circuit of the boiler and the room heating units connected thereto through pipes, a three-way valve is provided. The valve is arranged so as to connect the primary circuit or the secondary circuit to the water mains or to disconnect both therefrom. When the filling with water of the primary circuit and the room heating units is required, the three-way valve connects the primary circuit to the water mains, while during the normal operation of the boiler the three-way valve connects the secondary circuit to the water mains.

[0005] CN 210979822 U is directed to a circulating fluidized bed boiler anti-leakage detection device which comprises an upper half ring and a lower half ring, an upper alloy layer installed on the inner side of the upper half ring, and a lower alloy layer installed on the inner side of the lower half ring. The upper half ring and the lower half ring are combined to form a fixing ring, and the upper alloy layer and the lower alloy layer are combined to form an anti-leakage layer. In addition, a mounting base is formed on the upper half ring, a printed circuit board (PCB) is installed in the installation base, a processor is installed on the PCB, an ultrasonic sensor is installed below the PCB, the ultrasonic sensor being in signal connection with the PCB, and a gas sensor and a buzzer are installed in front of the installation base and are in signal connection with the PCB.

[0006] EP 2 366 962 B1 is directed to a boiler assembly comprising a removable domestic boiler unit detachably connected to a manifold unit, the arrangement being such that the manifold unit provides the boiler unit with a connection interface to a heating pipework system. The boiler unit can be quickly and simply removed from the manifold unit and taken away to be serviced or repaired. In order that the heating system may be used while the servicing is being carried out a replacement boiler unit is connected to the manifold unit. The boiler unit comprises a plurality of removable panels. The front panel comprises a security lock. A timer is also provided for turning the boiler unit on and off and to indicate when a service is due or to indicate a fault.

[0007] EP 3 279 571 A1 is directed to a control system of a heating plant comprising a boiler for heating a fluid, at least one supply pipe, through which the heated fluid is sent to one or more radiators, and at least one return pipe, through which the fluid from the radiators returns to the boiler. The plant comprises at least one circulator, wherein the control system further comprises a control unit adapted to control the boiler and the at least one circulator, a return temperature sensor, associated with a return pipe, and an outdoor temperature sensor adapted to measure the outdoor temperature, from the comparison of which a reference index is obtained which is essential for correct management of the heat to the building in which the heating plant is installed.

[0008] US 2019346131 A1 is directed to a method, system and computer program for detecting a boiler leakage, in which the automation system of the recovery boiler receives an indication of a need to start the automatic sequence and starts an automatic sequence with the following functions: stopping the dosing of the tracer into the boiler water, stopping the exhaust purge flow of the boiler water, monitoring a property of the boiler water over the duration of the inspection period and drawing a conclusion regarding the leakage on the basis of said monitoring. In order to prevent widespread damages, monitoring the tightness of the boiler is arranged such that a leakage is discovered already, when it is relatively small. The tightness of a boiler can be monitored by mass

balance monitoring, chemical balance monitoring, or acoustic emission monitoring.

[0009] Regarding toxic or asphyxiating gas leakage, this refers to harmful gas concentrations, such as carbon monoxide, building up in a room over time. The particular danger of carbon monoxide is that it is an odourless, tasteless and colourless gas. Most people begin to feel the acute effects of carbon monoxide exposure at 70 parts per million (ppm), while lower levels usually do not bring on obvious acute symptoms, however, also chronic exposure to low concentrations over an extended period of time can be harmful. Chronic exposure to low concentrations can for example lead to neurological symptoms. The early symptoms of acute carbon monoxide poisoning have a high similarity to cold or flu-like symptoms which are easy to ignore, such as shortness of breath, nausea, and mild headaches. Disorientation, impaired vision, and unconsciousness can occur when concentrations of carbon monoxide reach 150 ppm. Depending on the actual concentration, such acute symptoms can occur within minutes or within hours.

[0010] Conventional solutions are separate carbon monoxide detectors which give a loud alarm to prevent carbon monoxide poisoning. Such carbon monoxide detectors need to be placed at eye level and not on the ceiling and should not be placed further than 1,5 m from the source where carbon monoxide leakage may occur. The advice on conventional detectors is that they should be checked periodically, batteries exchanged as instructed, even in case of a wired sensor with a battery backup. This need for proper installation and maintenance e.g. by the homeowner has the disadvantage that the sound of such an alarm may not be heard in time, the battery status of the carbon monoxide detector may be low unnoticed, or the placement is improper with regard to height and location, so that the detection is less effective.

[0011] The sensor or sensors optionally check periodically the gas concentration. In particular, the sensor or sensors check the gas concentration at every start or after a predetermined time interval, in particular every 5 minutes.

[0012] Carbon monoxide detectors sound an alarm when they sense a certain amount of carbon monoxide over time; usually before first physical symptoms should develop. At lower concentrations (50 ppm), it may take up to eight hours for the alarm to go off. Higher levels (over 150 ppm) can trigger an alarm within minutes. Upon hearing such an alarm, actions should be taken quickly because exposure to low concentrations over extended periods of time can be as dangerous as sudden exposure to high concentrations of carbon monoxide. Once the carbon monoxide alarm sounds, the carbon monoxide detector must be in a carbon monoxide-free environment to silence the siren.

[0013] The known embodiments are not suitable to avoid an explosion or toxic or asphyxiating gas leakage triggered by the operating components of the boiler, once a gas leak is present.

[0014] The object of the invention is therefore to provide a safety mechanism that is easy to implement and by means of which a dangerous situation, in particular a dangerous situation for human health, can be prevented.

[0015] The object is solved by a safety mechanism for a boiler, the mechanism comprising:

a control unit for controlling the operation of the boiler;
r; and

at least one sensor connected to the control unit to measure gas, in particular hydrogen and/or carbon monoxide, concentration,
wherein the control unit is configured to determine whether a risk situation exists on the basis of the measured gas concentration and is configured to cause to switch the boiler in a safety operation mode when the risk situation exists.

[0016] A further object of the invention is to provide a method that is easy to implement and by means of which a dangerous situation, in particular a dangerous situation for human health, can be prevented.

[0017] The object is solved by a method for operating a boiler, in particular a hydrogen boiler, the method comprising:

receiving a gas concentration,
determining whether a risk situation exists on the basis of the measured gas concentration, and
switching the boiler to a safety operation mode when a risk situation exists.

[0018] An advantage of the safety mechanism is that it is easy to implement and that it does not take up a significant amount of space, in particular mounting space. Additionally, by switching the operation of the boiler to a safety operation mode when the risk situation exists, it can be easily prevented that the dangerous situation occurs.

[0019] A dangerous situation is a situation in which a danger for human health exists. This situation can result from that a leaked gas has reached an explosive level. An unwanted explosion can then be triggered by the operating components of the boiler. Additionally, a dangerous situation exists if the leaked gas is toxic or is asphyxiating.

[0020] It is noted that with safety mechanism is intended here a set of mechanical and/or electrical parts working together.

[0021] The safety mechanism can be advantageously used for a boiler that combusts a combustion gas. The combustions gas can be a gas mixture of air and fuel gas. The fuel gas can be a natural gas, methane, ethylene, propane, butane, coal gas, biogas etc., mixtures of the same, and mixtures of the same additionally comprising hydrogen or hydrogen, in particular pure hydrogen. Pure hydrogen is present if the fuel gas has at least a value comprised between 95mol % and 98 mol% of

hydrogen.

[0022] The boiler can be a pneumatic or electronic combustion boiler. The boiler can be a hydrogen boiler. A hydrogen boiler is a boiler to which fuel gas is supplied that comprises at least 95-98 mol % hydrogen. In particular, pure hydrogen can be supplied to the hydrogen boiler. In fact, although such type of boilers are environmentally friendly by reducing carbon emission, hydrogen is a high flammable gas and the safety mechanism can efficiently be used to prevent explosions, especially in heating systems for domestic use.

[0023] As is discussed below more in detail in the safety operation mode the operation of the boiler can be interrupted. This can be achieved by interrupting the combustion gas supply, in particular air and/or fuel gas, to the boiler. In the safety operation mode all actions of operating components of the boiler can be stopped in order to prevent to trigger an explosion for example.

[0024] The sensor used in the safety mechanism can be configured to detect and measure the concentration of the gas used as combustible fuel for the boiler and/or to detect and measure the concentration of the flue gas result of the combustion. In particular, the sensor can be a catalytic or semiconductor sensor to measure the concentration of hydrogen and/or to measure the concentration of carbon monoxide. A detection signal comprising information about the gas concentration can be generated and directly sent to the control unit. The sensor can send to the control unit several detection signals associated to different gas concentrations.

[0025] Carbon monoxide sensors can be different types of sensors. Biomimetic sensors comprise a gel which changes colour when the gel absorbs carbon monoxide, and this colour change is measured by the sensor. Metal oxide semiconductor sensors comprise a silica chip circuitry which detects carbon monoxide. Carbon monoxide lowers the electrical resistance, and this change is measured by the sensor. Also electrochemical sensors are suitable. The electrodes in a chemical solution sense changes in electrochemical potential when carbon monoxide comes in contact with the solution, and this change is measured by the sensor.

[0026] The control unit is an electric or electronic control unit. Additionally, the control unit is adapted to receive electric sensor signals and to output electric control signals. The control unit can comprise at least one processor and/or a printed circuit board.

[0027] According to one embodiment, the control unit can cause the switch of the boiler to the safety operation mode when the gas concentration is above a predetermined threshold value. In this case the risk situation can be easily determined. In particular, it can be recognized in time, i.e. before the dangerous situation occurs, that a risk situation exists if the gas concentration is too high. Therefore, countermeasures can be timely initiated. The sensor can be configured to send the aforementioned detection signal only to the control unit when the gas concentration is above the predetermined threshold val-

ue. Additionally or alternatively, the control unit can check whether the measured gas concentration is above the predetermined threshold value. If this is the case, the control unit determines that a risk situation is present.

[0028] As discussed above one countermeasure could be that in the safety operation mode the control unit causes the interruption of the operation of the boiler. In particular, the control unit can stop any activity of the boiler when a risk situation is determined and the boiler is switched to the safety operation mode. In this case, the boiler can remain in stand-by showing a specific error code on a corresponding display. All the dynamic components inside the boiler (i.e. fan, pump,...) can be stopped to avoid any possible trigger with the gas and consecutively possible explosion. As is discussed above in the safety operation mode it is possible that a fan of the boiler keeps running. In particular, the fan can run with same speed as in the normal operation mode or ramp up with or without time delay after the boiler is switched to the safety operation mode. The running fan ensures that the explosive or toxic or asphyxiating gas is evacuated from the cabinet of the boiler.

[0029] The threshold value can be predetermined e.g. in a laboratory and can be stored in the control unit. Specifically, the threshold value can for example be set between 20% and 35% of a danger gas level, and preferably at 25% of the danger gas level. A danger situation exists if the concentration is or is above the danger gas level. The danger gas level is the gas level from which a danger for human health exists. By setting the threshold far below the danger gas level it can be secured that the control unit recognizes the occurrence of a risk situation in good time before the danger situation occurs. This leaves time to initiate countermeasures when the boiler is switched to the safety operating mode. Additionally, people have enough time to leave the room.

[0030] It is noted that if a gas leakage is present but the sensor measures a gas concentration below the threshold value, nothing happens and the boiler continues to operate in the normal operation mode. This means that the safety mechanism switches the boiler to the safety operation mode only when a risk situation actually exists, thereby avoiding an unnecessary shut down of the boiler, in case the gas concentration would never lead to a risk situation.

[0031] The sensor can be hydrogen sensor. The hydrogen sensor can measure a concentration from 0 to 40,000 ppm and/or response within two seconds. The danger gas level is about 40,000 ppm. Therefore, the threshold can be set at 10,000 ppm so that the dangerous situation exists when the concentration is above 10,000ppm. The sensor can be arranged inside the boiler to verify leakage that could create possible explosion.

[0032] The sensor can be carbon monoxide sensor. Said sensor can be arranged outside the boiler in order to detect toxic gas. A threshold for deciding whether a risk situation exists depends from the type of carbon monoxide sensor. In particular, the threshold can be a fixed

value or an accumulated value over time.

[0033] In case the sensor is configured to detect the carbon monoxide concentration, the sensor detects a build-up of carbon monoxide concentrations over time. Lower concentrations 50 ppm, it may take up to eight hours for the threshold value of the sensor to be reached for the safety mechanism to interrupt the operation of the boiler only when a risk situation actually exists, thereby avoiding an unnecessary shut down of the boiler, in case the gas concentration would never reach harmful levels neither acute or chronically. Higher levels, over 150 ppm, can initiate the safety mechanism to interrupt the operation of the boiler within minutes. This has several advantages. The location of the carbon monoxide sensor can be placed in the proper location to the boiler as a potential source of carbon monoxide leakage and sensor maintenance and replacement can be a regular part of the maintenance of the boiler itself, thus reducing the risk of improper placement of the sensor or malfunction of the sensor due to aging or neglect.

[0034] The carbon monoxide sensor placed next to the boiler can be placed higher than the boiler. Alternatively, the carbon monoxide sensor can be placed in the cabinet at ceiling level or at an upper end of the cabinet or the boiler room.

[0035] In a particular embodiment in the safety operation mode of the boiler a warning signal can be outputted when the concentration of carbon monoxide is 25 ppm. An alarm signal can be outputted when the concentration of carbon monoxide is below 50 ppm. For the case that the concentration of carbon monoxide is 50 ppm for longer than 30min, the boiler stops combusting. In particular, gas valves for supplying the boiler with air and/or fuel gas can be closed.

[0036] Alternative processes can be used to determine whether a risk situation exists. For example, the interruption of the operation of the boiler can occur when the measured gas concentration increases according to a specific trend or function or when the measured gas concentration continuously increases in a predetermined period of time.

[0037] In one advantageous embodiment, the safety mechanism can comprise a plurality of sensors all connected to the control unit so that the gas concentration can be measured in different locations. In particular, the safety mechanism can comprise a first sensor and a second sensor, in particular electrically or electronically, connected to the control unit to measure the gas concentration, respectively. The sensor or sensor can wirelessly communicate with the control unit.

[0038] The two sensors can be spaced apart and are controlled by the control unit to independently acquire the measured data from two distinct locations. The switch of the boiler to the safety operating mode can occur when at least one of the first or second sensor determines that a risk situation exists.

[0039] The two sensors can be configured to measure the concentration of the same gas or, alternatively to

measure each the concentration of a different gas. Based on the gas concentration that is intended to be measured and based on the position of each sensor, both the first sensor and the second sensor can be configured to measure the concentration of hydrogen or both the first sensor and the second sensor can be configured to measure the concentration of carbon monoxide. Alternatively, one of the two sensors, the first or the second sensor, can be configured to measure the concentration of hydrogen, whereas the other sensor can be configured to measure the concentration of carbon monoxide.

[0040] The sensor or sensors can be used to measure the concentration of a gas, in particular carbon monoxide or hydrogen, in a flue gas. The flue gas results from combusting of combustion gas in the boiler. It is noted that for this purpose a different level concentration of the gas would be detected.

[0041] The sensor and/or control unit can be adapted to generate an error code when the risk situation is present. The error code simplifies the user of the boiler to identify the problem and/or the present risk situation. The control unit can receive the detection signals from the two sensors independently. Based on the gas concentration, i.e. based for example on the fact that the threshold value is exceeded, two different error codes can be displayed on a monitor. In particular, it is possible to select on the monitor the information (i.e. the measured values of the gas concentration) related to only one of the sensors or both sensor at the same time. The monitor can be located close to the boiler or boiler's cabinet or remotely.

[0042] The sensor has its own life, for example in case of a catalytic sensor the life is usually 4 to 5 years. After this period, the sensitivity of the sensor decreases and the response is less "reactive". Therefore, the mechanism can further comprise a timer synchronized with the activity of the at least one sensor. In particular, the timer can be configured to inform regarding the sensitivity reduction of the sensor. The timer is part of the safety mechanism and/or can be inside or outside the gas boiler and/or can be controlled by the control unit. The timer can be activated when the sensor is first installed and a life time is set based on the characteristics of the sensor. At the end the time set, a message or a signal can be generated to inform that the life of the sensor is expired or is going to expire, and a replacement is needed. The message or the signal can be displayed on a monitor.

[0043] According to another aspect of the invention, a heating system with a gas boiler and an inventive safety mechanism is provided. The boiler is connected with the safety mechanism through the control unit that controls one or more operating components of the boiler. With the term "operating component" is intended any component of the boiler used for its functioning. For example, the operating components can comprise a fan, a pump, a valve, a motor, an ignition system, etc.

[0044] It is noted that in this context, "heating system" can be intended as a gas boiler with the corresponding

operating components, wherein the safety mechanism described above can be arranged inside or outside a boiler's cabinet. The "heating system" can also comprise additional heating equipment, such as for example gas conduits, water conduits, and/or at least a radiator connected to the water conduits.

[0045] In one embodiment, as mentioned above the control unit can be located inside the cabinet and configured to close a valve located outside the cabinet for interrupting the inlet of combustible fuel supplying the boiler dependent on the measured gas concentration. In this way, if the risk situation is detected, in addition to stop any activity of the boiler, the introduction of additional combustible fuel or combustion products inside the cabinet is prevented. This considerably increases the safety of the system, especially when the combustible fuel is a high flammable element like hydrogen.

[0046] The first sensor of the safety mechanism can be positioned inside the cabinet of the boiler to measure the concentration of the gas inside the boiler. In this way, it is possible to promptly determine whether in the surroundings of the operating components of the boiler the risk of triggering an explosion exists. For example, the first sensor can be used to detect the leakage due to deteriorated internal connection pipes of the operating components. Advantageously, the first sensor can be directly integrated in the cabinet of the boiler or in the boiler components.

[0047] To efficiently detect the gas concentration, the first sensor can be positioned at an upper end of the cabinet, for example directly attached to the roof. This is particularly advantageous when using a hydrogen boiler. In fact, since the specific weight of hydrogen is lower than that of air, in a mixture of hydrogen and air, hydrogen moves quickly upwards and can be detected more efficiently.

[0048] To measure the concentration of the gas outside the boiler, the second sensor of the safety mechanism can be located outside the cabinet. The second sensor can be for example positioned and attached to an external wall of the cabinet or spaced apart from the cabinet in a strategic location, for example close to the conduit of the combustible fuel gas used for supplying the boiler. In this way, the second sensor can be used to detect if there is a risk situation outside the boiler, in particular outside the cabinet, due for example to a gas leakage of deteriorated or damaged conduits of the fuel gas. In particular, the second sensor can be used to measure the gas concentration in the room containing the boiler or the heating system.

[0049] To increase the safety of the system, the control unit can be configured to open an auxiliary output valve dependent on the measured gas concentration, i.e. when a risk situation exists. The output valve can be placed on a wall of the boiler's cabinet for ensuring the outlet of dangerous gas from the boiler or cabinet. By determining the risk situation, the operating of the boiler can be immediately stopped in the safety operating mode. At the

same time, the control unit can open the auxiliary output valve where is possible to connect an external gas valve that shut off the gas supply pressure. This increases the safety of the heating system.

[0050] To further increase the safety, the control unit can be configured to close a gas valve located outside the boiler for interrupting the inlet of combustible fuel supplying the boiler depending on the measurement of gas concentration. Also, the control unit can be configured to interrupt the operation of the boiler being in the safety operation mode by shutting off and/or closing the at least one operating component of the boiler.

[0051] Furthermore, the method can comprise immediately activating one or more actuators located inside and/or outside the boiler, when a risk situation exists. The actuators can be for example integrated in the valves that can be opened or closed to block or deviate the gas flow. Alternatively, the actuators can be separate components that act on the valves.

[0052] It is noted that if the leakage is downstream of the above-mentioned gas valve, i.e. in the cabinet of the boiler, the explosion possibility can be avoided because the system immediately reacts by controlling the actuators to act on the gas valve, fan, etc. upon detecting the gas concentration using the first sensor located inside the cabinet. If the leakage is upstream of the gas valve, i.e. outside of the boiler, the second sensor installed outside the cabinet of the boiler can avoid that the boiler is the cause of the trigger of the explosion.

[0053] In one embodiment, the heating system can comprise at least one fuel cell and/or heat pump and the at least one sensor is configured to detect concentration of the gas used to supply the fuel cell. The sensor or sensors can be used to measure the concentration of the refrigeration gases. A leakage of said gases can also lead to a dangerous situation.

[0054] According to an additional aspect of the invention, a use of a safety mechanism as described above for leakage detection in a gas boiler or in a heating system is provided.

[0055] Additionally, an advantageous embodiment is a computer program product comprising instructions which, when the program is executed by a control unit, cause the control unit to perform the inventive method. Furthermore, a data carrier is provided on which the computer program is stored and/or a data carrier signal is provided which transmits the computer program.

[0056] 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 standard heating system for domestic use as known from the prior art,

Figure 2 shows a schematic representation of a heating system including an safety mechanism

- according to one embodiment of the invention.
- Figure 3 shows a schematic representation of a heating system including a safety mechanism according to another embodiment of the invention and a boiler in detail,
- Figure 4 shows a schematic representation of a heating system including a safety mechanism according to another embodiment.
- Figure 5 shows a flow chart of a method according to one embodiment.

[0057] With reference to Figure 1, a standard heating system 30 for domestic use is shown. The figure illustrates the basic equipment used to heat for example a family residence. A boiler 20, for example a gas boiler, is located in a dedicated boiler's room 32 and is supplied by fuel gas. For example, a gas container 38 can be located outside the family residence and the fuel gas is transported in the family residence and then in the boiler 20 through gas conduit 33. By means of dedicated water conduits 31, heated water can be distributed in the several radiators 34 located in different external rooms 36 of the residence and returning cooled water can be transported back to the boiler 20 to be heated again passing through a heat exchanger.

[0058] It is noted that a gas leakage can have different causes. For example, the gas conduit 33 inside the boiler's room 32 can be damaged and part of the fuel gas can fill the boiler's room 32. A gas leakage can also occur inside the boiler 20, that is inside the cabinet containing the boiler 20 due for example to defective internal components of the boiler 20. Additionally, the gas leakage can originate from the exhaust flue gas generated by the combustion in the boiler 20. In all these cases, the boiler's room 32 or the boiler's cabinet can fill itself with toxic and above all flammable gas, resulting in a dangerous situation. In particular, in said situation there can be risk of explosion.

[0059] The explosion can be triggered by the operating components of the boiler 20 that, despite the gas leakage, can still continue to work. It is evident that such an explosion can be very dangerous since the boiler's room 32 is usually integrated in the family residence and can cause a collapse of the entire building. It is noted that different types of gas detection systems, known in the art, can be installed in the boiler's room 32. However, they are not always efficient in preventing explosions, especially triggered by the operating components of the boiler 20.

[0060] In addition or alternatively, a not correctly serviced boiler 20 can produce high concentrations of carbon monoxide, in case it is operated on natural gas or natural gas mixtures. Such a leakage can lead to toxic levels of carbon monoxide in the family residence, if despite the

gas leakage, the boiler still can continue to work. The particular danger of carbon monoxide is that it is an odourless, tasteless and colourless gas. Conventional solutions are separate carbon monoxide detectors which give a loud alarm to prevent carbon monoxide poisoning. Such carbon monoxide detectors need to be placed at eye level and not on the ceiling and should not be placed further than 1,5 m from the source where carbon monoxide leakage may occur. This has the disadvantage that the sound may not be heard in time, the battery status of the carbon monoxide detector may be low without anyone noticing or the placement is not properly done, so that the detection is less effective. Thus, the conventional sensors may not respond in time to prevent the onset of chronic or acute symptoms due to improper placement or neglect of the conventional carbon monoxide detector.

[0061] Figure 2 describes a heating system 30 with a safety mechanism 10 according to one embodiment of the present disclosure and a boiler 20. The system 30 comprises a boiler 20 including several operating components 26. The safety mechanism 10 comprises a control unit 24 for controlling the operation of the boiler 20. The boiler 20 is electrically connected with the safety mechanism 10 through the control unit 24 that controls the operating components 26 of the boiler 20. The control unit 24 can send control signals by means of the electrical connection to the boiler 20. For example, the operating components 26 include a fan, a motor, an ignition system, etc... Additionally, the safety mechanism 10 comprises a sensor 28 connected to the control unit 24 to measure gas, in particular hydrogen and/or carbon monoxide, concentration.

[0062] The control unit 24 is configured to determine whether a risk situation exists on the basis of the gas concentration measured by the sensor 28. For example, the risk situation occurs when the gas concentration exceeds a predetermined threshold value. In fact, if the measured gas concentration exceeds a determined critical dangerous gas level means that a gas leakage is present. The control unit 24 is also configured to cause to switch the boiler 20 to a safety operation mode when said risk situation exists. In the safety operation mode one or more of the operating components 26 are shut down. In this way, a dangerous situation like an explosion triggered by the operating components 26 of the boiler 20 or a toxic or asphyxiating gas leakage can be prevented.

[0063] In case of the sensor 28 measuring carbon monoxide concentration over time has several advantages. The location of the carbon monoxide sensor can be placed in the proper location to the boiler 20 as a potential source of carbon monoxide leakage and sensor maintenance and replacement can be a regular part of the maintenance of the boiler 20 itself, thus reducing the risk of improper placement or malfunction of the sensor due to aging or neglect.

[0064] In the shown embodiment, the sensor 28 measures the gas concentration outside the boiler 20. The

control unit 24 is located outside the boiler 20.

[0065] Figure 3 describes in detail a boiler 20. The boiler 20 comprises several operating components that are located inside a cabinet 22. The components comprise at least a fan 26A, a burner 26B and a heat exchanger 26C. The functioning of these components 26A, 26B, 26C is controlled by the control unit 24 that is also located in the cabinet 22. It is noted that the control unit 24 also controls the functioning of other elements, such as the opening or closing of inlet or output valves. The hydrogen gas enters the boiler's cabinet 22 through a gas conduit 21. A gas valve 27A, located outside the cabinet 22 can be opened or closed by the control unit 24 to regulate the gas inlet. The control unit 24 causes that the gas valve 27A is closed in case of a hydrogen leakage.

[0066] Prior to combustion, the hydrogen is mixed with air introduced in the cabinet 22 through an air conduit 23. In particular, hydrogen and air are forced or blown into the boiler 20 using the fan 26A. The gas mixture is ignited by an ignition system in the burner 26B. The combustion of the gas mixture results in hot flue gas which flows through the heat exchanger 26C transferring heat to the water system. The flue gas is ducted to the top of the cabinet 22 and exits the cabinet 22 through an exhaust conduit 25.

[0067] The control unit 24 is connected to a first sensor 28A and a second sensor 28B both located outside the cabinet 22 and placed and attached to an wall of said cabinet 22, respectively. The first sensor 28A can be placed close to the gas conduit 21. However, the first sensor 28A can be placed in other regions of the boiler 20. A correct placement of the first sensor 28A can be selected based on the geometry of the boiler's cabinet 22, the arrangement of the operating components inside the boiler 20 as well as the velocity of the gas, in this case the hydrogen gas. Fig. 3 shows the first sensor 28A to be located inside the cabinet, however, in another non-shown embodiment the first sensor 28A can be located outside the cabinet. Additionally, in an alternative embodiment the first sensor 28A can be arranged below the cabinet 22 or above the cabinet 22. The electrical connection between the sensors 28A, 28B and the control unit 24 is shown by dotted lines. It is noted that both the first sensor 28A and the second sensor 28B do not necessarily need to be in contact with the structure of the cabinet 22.

[0068] In addition, an internal timer 29 is present. The timer 29 is connected to the control unit 24 and is synchronized with the activity of the first sensor 28A and the second sensor 28B. It is noted that figure 3 shows the presence of a single timer 29 for both the first and second sensor 28A, 28B. However, it is also conceivable the presence of a dedicated timer for each sensor. The timer 29 is activated when the sensor 28A, 28B is first installed and a life time is set based on the characteristics of the sensor 28A, 28B. At the end of the time set, a message or a signal is generated to inform that the life of the sensor 28A, 28B is expired, or is going to expire, and a replacement is needed.

ment is needed.

[0069] The presence of two sensors, a first sensor or internal sensor 28A and a second sensor 28B serves to monitor, i.e. detect and measure, the gas concentration in different locations. The first sensor 28A is a hydrogen leak sensor used to detect and measure at least the variation of hydrogen. The first sensor 28A can also be a specific sensor configured to detect hydrogen, methane and LPG. Since hydrogen is a high flammable gas, it is very important to promptly detect a possible leakage. The first sensor 28A can efficiently detect a variation of the hydrogen concentration in case the leakage derives from the gas conduit 21 or from other conduits transporting the mixture of hydrogen and air. In fact, the location of the first sensor 28A in the upper end of the cabinet 22 makes it possible to easily detect this gas (hydrogen) in a mixture of hydrogen and air due to the different specific weight of hydrogen compared to air (hydrogen moves quickly upwards).

[0070] The second sensor 28B measures the gas concentration outside the cabinet 22 of the boiler 20. This is very useful to monitor the gas concentration, for example, outside the boiler. For example, the second sensor 28B may be placed close to the junction of the gas pipe to possibly detect a gas leakage at that location. In case the second sensor 28B is also a hydrogen leak sensor, it is possible to immediately understand whether the hydrogen leakage originates, for example, from a damage/deterioration of the hydrogen conduit external to the boiler 20 or rather from a damage/problem of an internal component of the boiler 20.

[0071] The combination of the internal and external sensors 28A, 28B definitely increases the safety of the entire heating system. In fact, in case the leakage is located downstream of the gas valve 27A, i.e. in the boiler 20, it is possible to avoid any type of explosion since the system reacts immediately interrupting the operation of the boiler 20 and eventually closing inlet valves, such as the gas valve 27A. In case the leakage is located upstream of the gas valve 27A, i.e. in the boiler's room, the second sensor 28B installed outside the boiler 20 can avoid that the boiler 20 is the cause of the trigger of the explosion.

[0072] It is noted that to increase the safety of the system, once a risk situation is determined, the control unit 24, in addition to interrupt the operation of the boiler 20 also closes the gas valve 27A, thereby interrupting the inlet of combustible fuel supplying the boiler, i.e. the inlet of hydrogen in the boiler 20. At the same time, the control unit 24 opens the auxiliary output valve 27B to eliminate dangerous gases from the cabinet 22. It is pointed out that the actuation of the gas valve 27A and the output valve 27B by the control unit 24 depending of the determination of a risk situation, is advantageously useful in case the first sensor 28A measures a critical gas concentration inside the boiler 20, i.e. inside the cabinet 22 of the boiler 20.

[0073] Figure 4 illustrates a schematic representation

of a heating system 30 for domestic use like that shown in figure 1 using the safety mechanism 10 as shown in figure 3. Additionally, the heating system 30 comprises the boiler 20. In particular, the figure shows the boiler 20 is placed in a boiler's room 32 separated from an adjacent external room 36 including a radiator 34 connected to the boiler 20 through water conduits 31. The water conduits 31 and the radiator 34 are part of the heating system 30.

[0074] Contrary to the embodiment shown in fig. 3, the first sensor 28A is placed at an upper side of the cabinet 22 of the boiler 20 to detect gas concentration, i.e. hydrogen concentration. The second sensor 28B is placed outside the boiler 20 in the boiler's room 32. Both the first and second sensor 28A, 28B are connected to the control unit 24 and can send detection signals to the control unit 24 based on the measurement of the gas concentration inside and outside the boiler 20, respectively.

[0075] Differently from the cases disclosed in prior art, and differently from the situation of figure 1, the presence of the internal and external sensors 28A, 28B ensures a more reliable detection of a gas leakage. In fact, the origin of the leakage can be promptly localized, i.e. inside or outside the boiler 20. In addition, based on the independent measurement of the sensors 28A, 28B, the operation of the boiler 20 can be interrupted, thereby preventing any explosion triggered by the operating components 26 of the boiler 20.

[0076] Figure 5 shows a flow chart of the method 100 for operation a boiler 20 using the safety mechanism 10 according to the invention.

[0077] The method 100 comprises the step of measuring S110 gas concentration using at least one sensor 28, for example the first sensor 28A and/or the second sensor 28B. At step S120, it is determined whether a risk situation exists on the basis of the measured gas concentration, for example if the gas concentration is above a threshold value.

[0078] If no risk situation is determined, the method returns to step S110 continuing monitoring the gas concentration. If, on the other hand, a risk situation is determined, the method proceeds to step S130. At step S130, the boiler 20 is switched to a safety operation mode. In the safety operation mode at least one operating component 26 of the boiler 20, for example the ignition system, a motor, a fan, a pump, etc., is shut off and/or closed. In addition, one or more actuators located outside the boiler 20 can be activated. For example, valves internal to the boiler 20 can be closed/opened to avoid the circulation of the gas in particular regions or valves external to the boiler 20 can be closed/opened to block or deviate the gas flow by means of the actuators.

[0079] Additionally, together with switching the boiler 20 to the safety operation mode, the method can comprise two more steps. Although these additional method steps increase the safety of the system, they are not considered essential for the method 100. At step S140, if a risk situation is determined, the gas valve 27A located

outside the boiler 20 is closed for interrupting the inlet of combustible fuel supplying the boiler 20. At step S150, if a risk situation is determined, the auxiliary output valve 27B is opened to permit the outlet of dangerous gas from the cabinet 22.

[0080] The method 100 can also comprise the step of generating a detection signal at the sensor and sending said detection signal to the control unit. The detection signal comprises information about the gas concentration. The control unit 24 can cause an alarm signal, for example acoustic signal and/or a message displayed on a monitor on the basis of the detection signal.

Reference Signs

[0081]

10	safety mechanism
20	boiler
21	gas conduit
22	cabinet
23	air conduit
24	control unit
25	exhaust gas conduit
26	operating components
26A	fan
26B	burner
26C	heat exchanger
27A	gas inlet valve
27B	output valve
28	sensor
28A	first sensor
28B	second sensor
29	timer
30	heating system
31	water conduit
32	boiler's room
33	gas conduit
34	radiator
36	external room
38	gas container
100	method

Claims

1. Safety mechanism (10) for a boiler (20), the mechanism (10) comprising:

a control unit (24) for controlling the operation of the boiler (20); and
at least one sensor (28) connected to the control unit (24) to measure gas, in particular hydrogen and/or carbon monoxide, concentration, wherein the control unit (24) is configured to determine whether a risk situation exists on the basis of the measured gas concentration and is configured to cause to switch the boiler (20) in

- a safety operation mode when the risk situation exists.
2. Safety mechanism (10) according to claim 1, **characterized in that**
 - a. the control unit (24) causes the switch to the safety operation mode of the boiler (20) when the gas concentration is above a predetermined threshold value or **in that**
 - b. the control unit (24) causes the switch to the safety operation mode of the boiler (20) when the gas concentration is above a predetermined threshold value wherein the threshold value is set at between 20% and 35% of a dangerous gas level, preferably at 25% of the dangerous gas level.
 3. Safety mechanism (10) according to claim 1 or 2, **characterized in that** the at least one sensor (28) is a catalytic or semiconductor sensor to measure the concentration of hydrogen or to measure the concentration of carbon monoxide.
 4. Safety mechanism (10) according to one of the claims 1 to 3, **characterized in that** the mechanism (10) comprises a first sensor (28A) and a second sensor (28B) connected to the control unit (24) to measure gas concentration, respectively.
 5. Safety mechanism (10) according to claim 4, **characterized in that**
 - a. both the first sensor (28A) and the second sensor (28B) are configured to measure the concentration of hydrogen, or
 - b. both the first sensor (28A) and the second sensor (28B) are configured to measure the concentration of carbon monoxide, or
 - c. the first sensor (28A) is configured to measure the concentration of hydrogen and the second sensor (28B) is configured to measure the concentration of carbon monoxide, or
 - d. the first sensor (28A) is configured to measure the concentration of carbon monoxide and the second sensor (28B) is configured to measure the concentration of hydrogen.
 6. Safety mechanism (10) according to one of the claims 1 to 5, **characterized in that** the mechanism (10) further comprises a timer (29) wherein
 - a. the timer (29) is synchronized with the activity of the at least one sensor (28) and/or **in that**
 - b. the timer (29) is configured to inform regarding the sensitivity reduction of the sensor (28).
 7. Heating system (30) with a boiler (20) and a safety mechanism (10) according to one of the preceding claims 1 to 6.
 8. Heating system (30) according to claim 7, **characterized in that**
 - a. the control unit (24) is contained in a cabinet (22) of the boiler (20) or arranged adjacent to a cabinet of the boiler (20) and/or **in that**
 - b. the control unit (24) is configured to close a gas valve (27A) of the boiler (20) located outside a cabinet (22) of the boiler (20) for interrupting the inlet of fuel gas, in particular hydrogen, supplied to the boiler (20) dependent on the measured gas concentration, and/or **in that**
 - b. the control unit (24) is configured to open an auxiliary output valve (27B) of the boiler (20) dependent on the measured gas concentration and/or **in that**
 - c. the first sensor (28A) is positioned inside a cabinet (22) of the boiler (20) to measure the concentration of the gas inside the boiler (20), and/or **in that**
 - d. the first sensor (28A) is positioned at an upper end of the cabinet (22) of the boiler (20), and/or **in that**
 - e. the second sensor (28B) is located outside a cabinet (22) of the boiler (20) to measure the concentration of the gas outside the boiler (20).
 9. Heating system (30) according to claim 7 or 8, **characterized in that** the system (30) comprises at least one fuel cell and/or heat pump.
 10. Method (100) for operating a boiler (20) the method (100) comprising:
 - receiving (S110) a gas concentration,
 - determining (S120) whether a risk situation exists on the basis of the measured gas concentration, and
 - switching (S130) the boiler (20) to a safety operation mode when a risk situation exists.
 11. Method (100) according to claim 10, **characterized in that** the step of interrupting (S130) the operation of the boiler (20) occurs when the gas concentration is above a predetermined threshold value, in particular when the threshold value is set at between 20% and 35% of a dangerous gas level, and preferably at 25% of the dangerous gas level.
 12. Method (100) according to claim 10 or 11, **characterized in that**
 - a. the gas concentration is measured by a first sensor (28A) and a second sensor (28B), both connected to the control unit (24) to measure

gas concentration and **in that** the step of interrupting (S130) the operation of the boiler (20) occurs when at least one of the first or second sensor (28A, 28B) determines that a risk situation exists and/or **in that**

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b. after a risk situation is determined the boiler is restarted and/or evacuated.

- 13.** Method (100) according to any one of claims 10 to 12, **characterized in that** the method comprises

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a. closing (S140) a gas valve (27A) located outside a cabinet (22) of the boiler (20) for interrupting the inlet of fuel gas, in particular hydrogen, supplied to the boiler (20) depending on the measurement of gas concentration, and/or

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b. switching (S130) the operation of the boiler (20) by shutting off and/or closing at least one operating component (26) of the boiler (20), and/or

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c. opening (S150) an auxiliary output valve (27B) of the boiler (20) when a risk situation exists.

- 14.** Use of a safety mechanism (10) according to any one of claims 1 to 6 for leakage detection in a boiler (20) or in a heating system (30) according to one of the claims 7 to 9.

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- 15.** Computer program product comprising instructions which, when the program is executed by a control unit (24), cause the control unit (24) to perform the method according to one of the claims 10 to 13.

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Figure 1

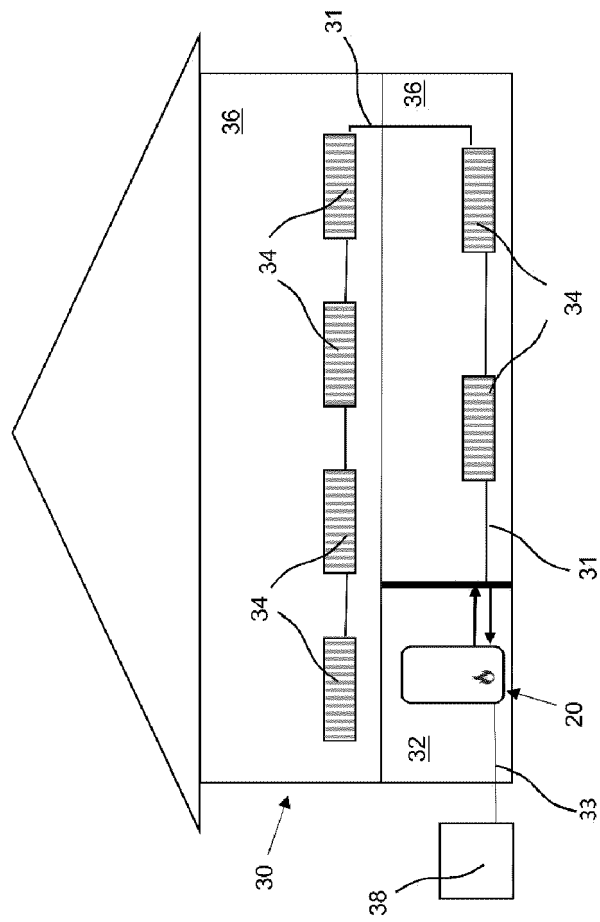
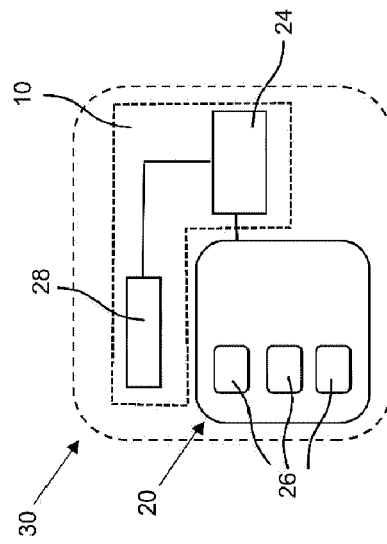


Figure 2



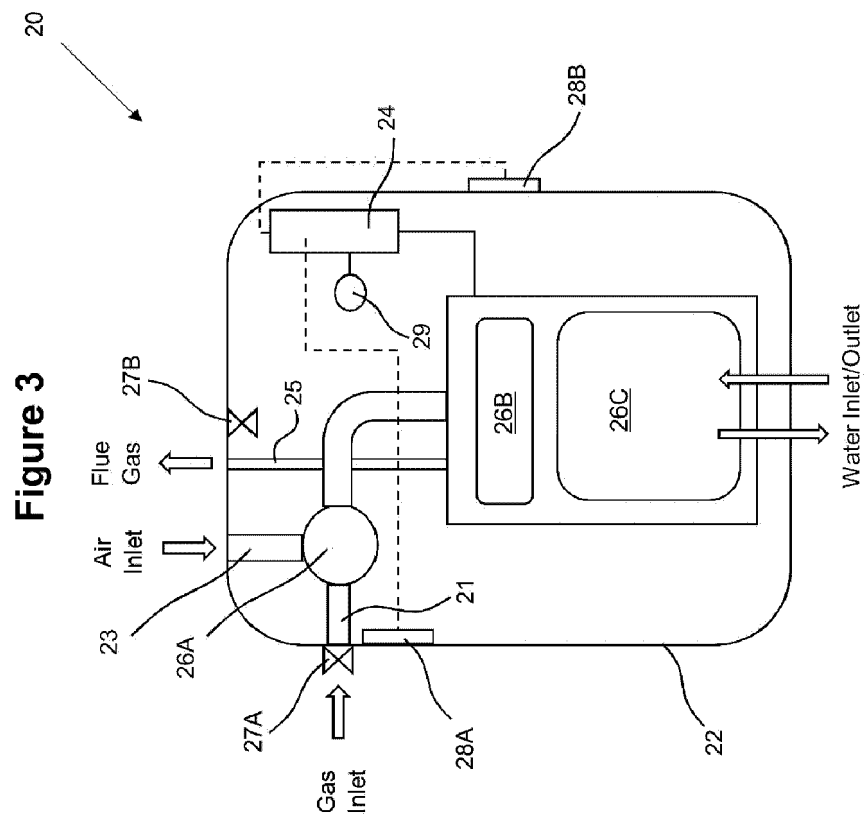


Figure 4

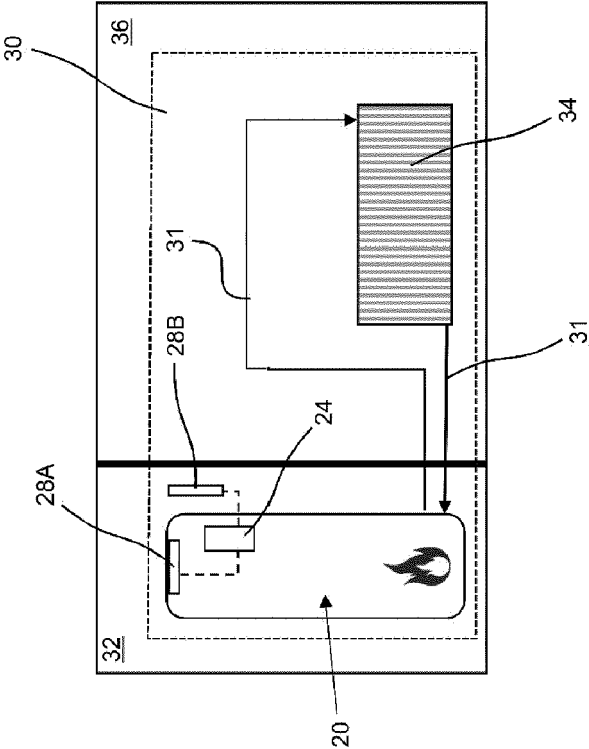
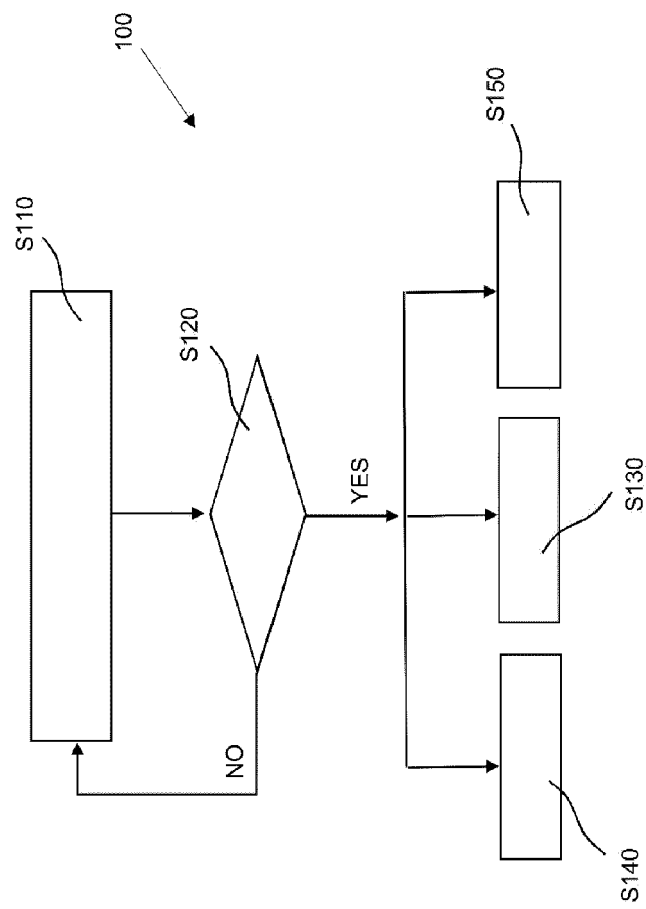


Figure 5





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 Application Number
 EP 21 17 9109

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Place of search Munich		Date of completion of the search 17 November 2021	Examiner Hoffmann, Stéphanie
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