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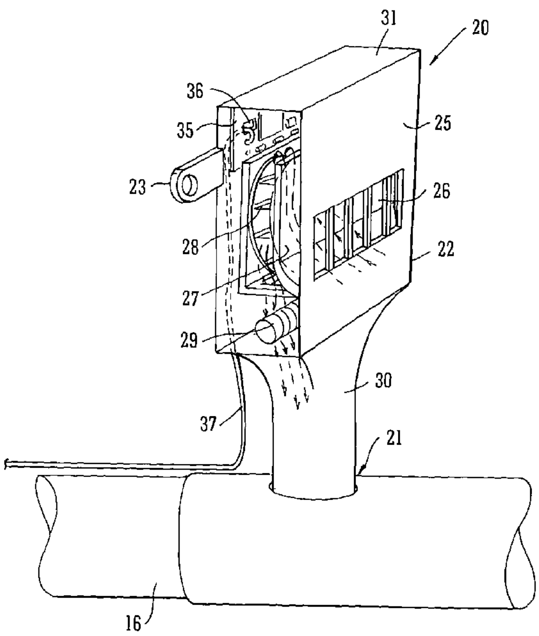

FIG. 3

(57) **Abstract**: For the inhibition of ice formation in a pipe such as the condensate pipe which is exposed to a low ambient temperature there is provided an electrically powered fan (28) and an electrically powered heater (29). The fan and heater are operated to provide a forced flow of heated air at a temperature above said ambient temperature and the heated air is introduced (21) into said pipe to flow in a direction towards the pipe outlet.

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Pipe Icing Inhibition (2)

This invention relates to an icing inhibitor for a pipe such as a condensate pipe, a method of inhibiting formation of ice in a pipe and an installation comprising the combination of an appliance which emits a flow of water, such as a flow of condensate, and an icing inhibitor which is operable to inhibit freezing of water in an outlet extending from the appliance.

For many types of thermal energy transfer apparatus, such as central heating boilers of the condensing type, and other appliances such as air conditioning apparatus, there is a requirement to ensure that condensate generated during use of the appliance is able freely to drain away from the appliance.

The invention relates in particular, though not exclusively, to a method for the control of an icing inhibitor having associated therewith a control module whereby an improved safety and or reliability of operation of the icing inhibitor may be achieved,

The drainage of condensate typically is through a pipe which terminates at or extends via a position exposed to the external environment and which, at at least some times of the year, is sufficiently cold as to cause condensate to freeze in the pipe. The propensity of the condensate to freeze can be exacerbated if the pipe terminates at or extends via a position where it is exposed to wind chill effects. In contrast to the periodic flow of a large volume of water through the relatively large diameter waste pipe from a sink, washing machine or the like, the relatively small volume, and often substantially continuous trickle of condensate from a condensate generating appliance results in the condensate being particularly prone to freezing at the outlet region of the condensate pipe, and subsequent blockage of the pipe.

In consequence of eventual blockage of the condensate pipe by formation of ice the appliance will cease to function properly. This problem is encountered both for an appliance installed within a building or other protective enclosure and which drains condensate externally, and also for an appliance installed at a location exposed to the external environment. Similarly, the same problem can arise with an appliance and condensate pipe outlet mounted internally in an unheated environment where the temperature can fall sufficiently to result in ice formation in the condensate outlet pipe.

In some cases it is possible for an internally installed appliance to drain into a larger diameter indoor waste pipe, such as that extending from a sink. However this is not always convenient, can involve significant cost in accessing the pipe without damage to permanently installed kitchen furniture and also does not ensure that the trickle flow of condensate will not freeze and cause even the larger diameter waste pipe also to become blocked.

In an attempt to address the problem of ice formation in a condensate pipe it has been proposed to fit a long flexible and electrically powered heater to the exterior of the condensate pipe, for example using cable ties, and then to surround the pipe with thermal insulation. However, in addition to the cost of the required equipment, there is a significant labour cost for effecting the installation. Also any errors made by the installer are not readily visible, these being in many cases hidden by the insulation, and are likely to be apparent only at the time of a subsequent failure to inhibit ice formation.

In another proposal as described in GB 2470519A an electrically powered heater wire is provided inside the condensate pipe. However this does not address the aforementioned issues of cost, time of installation and opportunities for installation error. Furthermore it is necessary to provide special connectors for introducing an electric cable into the pipe whilst maintaining a watertight seal.

Another known proposal is disclosed in GB 2474918A.

The aforementioned proposals to provide an electrically powered heater also pose requirements to ensure that there is safe and reliable operation without overheating and creation of a fire or other safety hazard.

In addition to the risk of freezing of condensate emitted from an appliance in consequence a condensing process substantially similar problems of freezing of water in pipes and consequential blockage can arise in other situations and require to be addressed.

The present invention seeks to provide an improved method, icing inhibitor device and installation for inhibition of ice formation in a pipe.

In accordance with one aspect of the present invention a method for inhibition of ice formation in a pipe which is exposed to a low ambient temperature comprises providing an electrically powered fan and an electrically powered heater, operating said fan and heater to provide a forced flow of heated air at a temperature above said ambient temperature and directing said forced flow of heated air through said pipe in a direction towards the pipe outlet.

The references herein to a low ambient temperature refer to an ambient temperature which is sufficiently low as to cause water to freeze and to an ambient temperature which in combination with any wind chill effects in the vicinity of the pipe will cause water to freeze.

The heater and the fan may be controlled in a manner that is a function of the outlet temperature of heated air and which may be the temperature of the air output of the heater or of heated air flowing through the pipe outlet, either at the very end of the pipe or at a position within and close to the end of the pipe. Thus a target temperature for heated air may be pre-established and, by use of a feed back control of the heater as a function of said temperature, preferably to maintain the temperature of said heated air substantially constant at said target temperature, there may be achieved an energy consumption rate which is sufficient to prevent freezing within the pipe. In consequence as well as ensuring a sufficient heat input to the airflow, the use of an unnecessarily high and wasteful energy input is avoided. This form of control also affords the benefit of ensuring that if the fan fails to operate or delivers a lower than intended airflow rate, or if the heater for other reasons might tend to overheat, the potential for permanent damage to the fan or heater is mitigated or avoided.

Preferably the fan is a constant speed fan and temperature control is achieved solely by control of the heater. However alternatively a variable speed fan may be employed and temperature control may be achieved by combined control of the heater and the fan speed.

The method is particularly, but not exclusively, directed to inhibition of ice formation in a pipe which carries a low volume flow, e.g. a trickle flow of water, whether a continuous or intermittent flow, such as the flow of condensate from a condensate producing appliance.

The method may comprise providing the forced air flow only when at least a part of the pipe, for example the pipe outlet, is exposed to a temperature at which water might freeze within the pipe or at the pipe outlet, and which may be either an ambient temperature at still air conditions or at a position exposed to wind chill effects.

The air may be introduced into the pipe at a position within an appliance, such as an appliance which produces the condensate, at a position close to an outlet of the appliance, or at any other position upstream of the distal, outlet end of the pipe.

In the case of a pipe which extends through the wall of a building, to drain externally, the air may be introduced into the pipe either at a position which is within the building or external thereof.

Said electrically powered fan and or said electrically powered heater may be provided either external of or within the pipe.

Preferably, however, the electrically powered device(s) for creating a forced air flow and for heating air is (are) positioned external of the pipe. Thus there is obviated any need to create in the wall of the pipe a sealed aperture for entry of an electric cable.

In one preferred method for an appliance which is within a building, and has a pipe extending outwards through an external wall of the building, air is taken from the external environment, heated and forced into the pipe by an icing inhibitor device positioned in the external environment, external of or surrounding the pipe.

Additionally or as an alternative to control of the heater or the heater and fan as a function of the temperature of heated air flowing towards or through the pipe outlet, the method of the invention may comprise provision of a sensor to detect the ambient temperature at or in the vicinity of the pipe outlet. Thus, although a sensor may be positioned at the pipe outlet, if supply means for providing the heated source of air is in the external environment, exposed to conditions similar or predictably related to those at the outlet end of the pipe, a sensor may be provided integrally with at least part of said supply means.

A control module may be provided to effect said forced flow of air through the pipe as a function of sensed or estimated ambient temperature. The rate of air flow and or temperature may be varied in relation to the ambient temperature such that, for example, in very cold conditions there is a high flow rate and/or high temperature of forced air as compared with the flow rate or temperature when the ambient temperature is higher, and for there to be no forced air flow or at least no heating effect when the ambient air temperature is greater than that at which water might freeze within the pipe. The sensor may be of a type which is sensitive to wind chill effects that may affect the propensity for water to freeze in the pipe, and the air flow temperature and/or rate of air flow may be a function of wind chill effects.

Variation of the rate of heat input to the flow of air, for example to vary the average temperature of the heated air, may be effected by variation of the power supply to an electrical heater, for example by variation of the current magnitude or frequency of energy input such as by pulse width modulation.

A method for the variation of the rate of heat input to the flow of air may comprise increasing the output of the heater as ambient temperature decreases, with the heater and operation of an airflow fan both being initiated when the ambient temperature has decreased to below a pre-established temperature, for example +5°C. Two temperature sensors may be employed, one at the air input to the heater and the other at or in the vicinity of the air output of the heater, for example on a heater heat shield. In operation of the heater the temperature at the air input of the heater can be expected to differ from the true ambient temperature because, for a compact installation and device, that sensor will be affected by proximity to the heater. To compensate for that difference between sensed temperature at the air input of the heater and actual ambient air temperature the method of the invention may employ extrapolation to estimate the ambient temperature by having reference to the temperature sensed at the air output of the heater, for example by using a linear or other predicted relationship between the air inlet and outlet temperatures of the airflow through the heater for a given rate of heat input.

In accordance with another aspect of the present invention an icing inhibitor for inhibiting formation of ice in a pipe such as a condensate pipe comprises an enclosure having an air inlet port and an air outlet for communication with a pipe, the enclosure containing an electrically powered fan for inducing air to flow into the enclosure through the air inlet port, and an electrically powered heater element, said icing inhibitor having associated therewith a heater control module whereby, in use with a temperature sensor which measures the temperature of heated air flow, the control module is operable to control the electrical power to the heater as a function of said temperature.

Additionally or alternatively the temperature sensor may be of a type which can be exposed to external air flow movements thereby to provide an indication of an effective temperature which may be less than the actual ambient temperature of the air and thus be more likely to cause freezing of water, especially if the positioning of the pipe is such that cold air can readily enter the pipe outlet. Thus the air flow temperature and/or rate of air flow may be controlled also to be at least in part a function of wind chill effects.

The heater control module may be secured to and/or be positioned within said enclosure. The enclosure may be provided with means, such as apertured lugs, to facilitate attachment to the external wall of a building. An enclosure for mounting externally may comprise a non-apertured face which, in use, is uppermost and one or more of the other faces may face horizontally or downwards and be apertured to provide the air inlet in a manner that inhibits ingress of rain.

In a further alternative for temperature control two temperature sensors may be provided within or at the surface of an enclosure, one at the air input position to the heater and the other at or in the vicinity of the air output of the heater, for example on a heater heat shield. Operation of the heater and the degree of heat input provided by the heater may be a function of the temperature sensed by either or each of said two temperature sensors. Operation of the heater may be a function of an estimated ambient air temperature which, when the heater is in operation to provide a heating effect, is determined by extrapolation of the temperature sensed at the air input of the heater by having reference to the temperature at the air output of the heater for a given rate of heat input. The icing inhibitor may comprise control means which applies a linear or other predictive relationship between the two sensed temperatures to provide an estimate of the ambient air temperature external of the enclosure.

The icing inhibitor may be of a type which operates at mains voltage or it may operate at a low voltage.

The icing inhibitor may comprise an outlet port for a supply of heated air which is introduced into the condensate pipe at a position external of said enclosure.

Alternatively the condensate may flow through the inhibitor and air may be introduced into the condensate pipe, or a junction between two sections of condensate pipe at a position within the icing inhibitor.

If heated air is introduced into the condensate pipe at a position within an enclosure and which is between two sections of condensate pipe, preferably the condensate from a first section is directed to flow into the second section at a position substantially centrally within the second section. Preferably said second section, when in an assembly installation, extends substantially vertically. Accordingly the condensate is discouraged from flowing in direct contact with the wall of the downstream outlet section of the condensate pipe.

In a construction in which heated air is introduced into the condensate pipe at a position which is within an enclosure and which is between two sections of condensate pipe a failsafe condensate flow path may be provided whereby, in the event of the outlet section of pipe becoming blocked, condensate is able to flow out of the pipe from between the two section thereof and flow outwards from the enclosure.

A first section of condensate pipe for introducing condensate to within the enclosure of the icing inhibitor may enter through one of the side or upper or lower faces of the enclosure. Alternatively it may enter directly through the rear of the enclosure, with the icing inhibitor thus being secured to the external wall of a building at a position aligned with the section of condensate pipe that extends through the wall of the building.

Preferably a flexible, resilient connector, typically of a type for push fitting into a condensate pipe, is provided at a position where the condensate pipe terminates at the external wall of a building. The flexible connector preferably is arranged to form a fluid tight seal with that section of condensate pipe and to ensure that condensate then flows through a further, downstream section of condensate pipe without risk of contacting the external wall of a building. Said flexibility of the connector is intended to provide a fluid tight connection whilst also accommodating any misalignment between the pipe extending through the wall of a building and the longitudinal axis of an entry port of the icing inhibitor. Accordingly the risk of acidic condensate damaging the building structure and foundations is minimised.

In accordance with yet another aspect of the present invention there is provided an installation comprising an appliance which emits water, whether as a liquid or vapour, a pipe for drainage of water from the appliance, a temperature sensor for establishing the ambient temperature at or in the vicinity of the outlet end of the pipe, an air supply device for forced flow of air through the pipe in a direction towards said outlet end of the pipe, said air supply device providing air at a temperature greater than the ambient temperature, and control means operable, at least when the appliance is operative to emit water, to provide a forced flow of air when the ambient temperature is indicative of a risk of ice formation in the pipe.

Said installation may comprise an icing inhibitor device of a kind in accordance with the present invention. Said installation may comprise a condensate producing appliance such as a thermal energy conversion appliance and wherein condensate is drained via said pipe.

In accordance with the regulations applicable in at least some territories, such as the UK, there is a requirement for a pipe such as a condensate pipe to be provided with a U bend. This is intended primarily to act to prevent foul aromas travelling up the pipe from an external drain to within a property. In that case the present invention provides an installation wherein a forced flow of air is introduced into the pipe at a position between the U bend and the distal, outlet end. The U bend therefore advantageously serves to ensure that air introduced into the pipe flows in a direction towards the outlet end of the pipe. However, if no U bend is provided, either a one-way valve, such as a simple flap valve may be provided to inhibit flow of air in a reverse direction along the pipe towards the appliance, or air may be introduced into the pipe in a direction parallel with the length of the pipe, thus being in contrast to entry via a simple T junction which would inject the air in a direction perpendicular to the length of the pipe.

The appliance may be of a type under the control of a timer which designates specific "on" periods and "off" periods, and during the "on" periods the appliance may operate either continuously or intermittently in response, for example, to the temperature of air in the environment which is being heated or cooled by the appliance. In that case the forced flow of air into the pipe may be controlled to occur only during all or at least some of the time for which the appliance is at an "on" period and the temperature sensor indicates the potential risk of water freezing in the pipe. The forced flow of air may be confined only to periods when the appliance is operative to emit water. In an alternative the forced flow of air may be confined to said "on" periods, or the times in the "on" period when the appliance is in actual operation potentially to emit water, and an additional period subsequent to the appliance not being in actual operation to emit water. That additional period may be pre-set or may be a function of the sensed ambient temperature such as the ambient temperature at or in the region of the pipe outlet.

The appliance may be under the control of means other than or additional to a timer. For example it may be under the control of a temperature or humidity sensor. In such cases the forced flow of air similarly may be confined to a period when the appliance is operative to emit water, or to a said period extended by an additional period.

In accordance with another aspect of the present invention there is provided an icing inhibitor for inhibiting formation of ice in a pipe such as a condensate pipe and comprising an electrically powered fan, an electrically powered heater and a control module to receive temperature information and control operation of the fan and heater as a function of received temperature information whereby in use the icing inhibitor is operable to provide a flow of heated air for inhibiting formation of ice in a pipe, said icing inhibitor further comprising a built-in test (BIT) facility operable in at least one of a one-off, intermittent and continuous mode to provide a BIT output indicative of whether or not a fault condition exists in respect of operation of at least said heater and fan.

The BIT facility may be provided in association with an icing inhibitor which comprises one or more of the other features described herein, such as a heater and fan positioned in an enclosure external of or through which a pipe extends, or air inlet and outlet temperature sensors.

The output of the BIT facility may be audible or visual or a combination of audible and visual. The BIT facility may provide a non-audible and non-visual signal which is transmitted to a remote location having means for providing an audible or visual BIT output. A particular suitable BIT output for many installations will be a visual output comprising one or more LEDs. For example, a green LED may be provided to indicate correct operation and a red to indicate a failure. An LED may be arranged to flash in two or more manners, for example at different frequencies or timed durations, thereby to indicate the specific nature of a fault or a failure mode.

The BIT facility may provide an output only when a fault condition exists, but preferably also provides an output that confirms absence of a fault condition.

The BIT facility may be operable in a one-off, test mode such as may be particularly applicable to testing the icing inhibitor when initially powered, for example as a final test in the manufacturing process or at the time of initial on-site installation. For this purpose the BIT facility typically will be arranged to power both the fan and the heater for a short period, irrespective of received information, to confirm correct operation of the fan and heater.

The BIT facility may be operable in an intermittent, confirmation mode to confirm at intervals, say weekly, that the icing inhibitor remains ready for correct operation. This may involve briefly powering the fan and heater to ensure their correct operation.

The BIT facility may be operable in an activity mode on a continuous basis, for example when a condensate generating appliance is active or when received temperature information is indicative of a risk of formation of ice, thereby continuously to monitor and confirm that, for example, the fan is on or off when commanded by the control module to be on or off,

In addition to testing the fan and heater for correct operation the BIT facility may interrogate and test other components of or associated with the icing inhibitor such that as a remote temperature sensor or the control module.

The BIT facility may be operable to test in respect of one or more of

Inlet temperature sensor is unreasonable; short circuit or open circuit fault

Outlet temperature sensor is unreasonable; short circuit or open circuit fault

Fan failed on; fan is off when commanded off. Allows for a power down delay and uses a 3rd wire on fan

Fan failed off; fan is off when commanded on. Allows for a power up delay and uses a 3rd wire on fan

Heater failed on; heater is on when commanded off. Allows for a power down delay and uses heater current

Heater failed off; heater is off when commanded on. Allows for a power up delay and uses heater current

Inlet over temperature i.e.> 100°C

Outlet over temperature i.e. > 100°C

Fan is running faster than expected – this is indicative of a partially blocked air path

The BIT facility may be operable to cause the icing inhibitor to operate in a reversionary mode when one or more specific aspects of the icing inhibitor are found to be defective. Thus, for example, a fan may be commanded "on" and the system may be given a target temperature of 20°C in a situation in which an input temperature sensor has failed. In this situation, although the pipe may freeze, the enclosure will not and there will be a path by which the condensate may exit the enclosure through the air inlet. This will allow the boiler to remain functional albeit that condensate may spill over the exterior wall of the property.

The invention yet further provides an icing inhibitor having one or more of the features described herein and in which the heater is under the control of an electronic switch of the bi-directional triode thyristor type, namely a TRIAC switch.

One known failure mode of a TRIAC switch is such that when the switch is used in an ice inhibitor of the present invention it could result in the heater switching on and remaining on, thus resulting in the heater potentially over-heating. Typically that feature of a TRIAC switch may be addressed by providing a delayed self re-setting feature but that has the disadvantage that the heater would then repeatedly cycle on and off for as long as power is present. Alternatively the problem may be addressed by permanently switching off the heater, but that then typically results in the fitting of a replacement even though the failure may have been a glitch, i.e. a one-off random operational failure without any significant risk of subsequent recurrence of that failure. In accordance with a yet further aspect of the present invention the method of operating an icing inhibitor having a heater controlled by a TRIAC switch comprises switching off the power supplied to the switch and then switching on thereby to re-set the switch. The icing inhibitor may incorporate or have associated therewith a warning device, such as the aforedescribed LED associated with a BIT output for providing the user with a warning of the need to re-initiate the power supply to the icing inhibitor.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:-

Figure 1 is a schematic diagram of an installation in accordance with one embodiment of the present invention;

Figure 2 is a view in the direction of arrow A of figure 1;

Figure 3 is a perspective view showing, part cut away, the icing inhibitor device of the installation of Figure 1 and part of the condensate pipe;

Figure 4 shows diagrammatically the inter-connection of component parts of the icing inhibitor device;

Figure 5 is a vertical sectional view of part of an installation in accordance with the second embodiment of the present invention;

Figure 6 shows in detail part of Figure 5, and

Figure 7 shows diagrammatically the interconnection of component parts of an icing inhibitor device in accordance with a third aspect of the present invention.

An icing inhibition installation 10 comprises a gas fired condensing type central heating boiler 11 which is under the control of an electrically powered timer 12 such that the boiler operates at pre-set "on" and "off" periods. Additionally an override "frost protection" facility 11a is provided whereby the boiler automatically adopts an operative "on" mode, even during a timed "off" period, when the temperature in the vicinity of the boiler approaches 0^0C, typically when it approaches 5^0C.

When at an "on" period the combustion of gas in the boiler results in the production of steam which is condensed and drained from the boiler via a condensate pipe 13. The boiler is secured to the inner face 14 of an outer wall 15 of a building and the condensate pipe extends through a hole 16 in the wall such that the outlet end 17 of the pipe directs condensate to an external drain or soak away 18.

To comply with building and other regulations in certain territories, such as the UK, the condensate pipe incorporates a U bend 19 in which a quantity of condensate is retained and serves to prevent foul aromas travelling up the condensate pipe to be at risk of entering the building, and/or adversely interfering with the combustion process within the boiler.

The flow of condensate through the condensate pipe from the boiler 11 to the U bend is safeguarded against the risk of freezing in consequence of the frost protection override facility 11a ensuring that the temperature in the boiler environment is sufficiently above the freezing point of water.

However the flow of condensate downstream of the U bend is prone to freezing, especially towards the distal end 17 where condensate may be exposed to a low temperature and wind chill effects.

To inhibit ice formation in the external downstream section of pipe warm air from an icing inhibitor device 20 is forced into the pipe via a T junction 21 at the position close to where the pipe exits from the wall.

The icing inhibitor device 20 (see Figure 3) comprises an enclosure body 22 in the form of a moulded plastics box having a pair of lugs 23 for enabling it to be secured to the external surface 24 of the wall 15 at a small distance (see Figure 2) above and to one side of the hole 16 through which the pipe extends.

The body 22 has a non-apertured top face 31 and a front face 25 formed with a grill 26 through which air can enter the enclosure body. A baffle 27 is positioned inwards of the grill, and is sealed to the lower edge of the grill opening such that any rain water ingressing through the grill contacts the baffle and drains back, outwards through the grill.

To the rear of the baffle 27 the enclosure supports an air impellor 28 which directs a forced flow of air downwards over an electrically powered heater element 29. Heated air then flows through an outlet pipe 30 to the junction 21 with the condensate pipe.

The vertically extending side faces of the enclosure body in common with top face are non-apertured but in the illustration of Figure 3 the side face nearest the lug formation 23 is shown as removed thereby to make clear the positioning within the enclosure body of the aforementioned components.

The enclosure body additionally supports a printed circuit board (PCB) 35 on which is mounted a temperature sensor 36 and microprocessor 39. Part of the sensor extends to a side face of the body to be exposed to the external temperature.

The printed circuit board is powered by a low voltage supply cable 37 which extends through the hole 36 from a transformer 38 connected to the mains electrical supply 38a within the building.

The manner in which the components are operationally interconnected within the enclosure body 20 is shown diagrammatically in Figure 4.

The PCB 35 receives power via the aforementioned low voltage supply 37. Power is then applied to the fan 28 and heater element 29 in dependence of the signal received by the processor 39 from the temperature sensor 36. In this embodiment the processor is operative to power the fan and heater when the temperature information received from the sensor 36 indicates a temperature below 3^0C.

The fan is of the constant speed type whereby the forced flow of air has a pre-determined velocity. However the processor 39 provides pulse width modulation control of power to the heater 29 such the lower the sensed temperature is below 3^0C the greater the average heating effect provided by the heater.

From the foregoing it will be understood that by virtue of the provision of a forced flow of heated air though the condensate pipe at all times when there is a possibility of the condensate freezing at the distal end 17 of the condensate pipe, freezing of the condensate and thus blockage of the pipe to disrupt efficient operation of the boiler is avoided.

In a modification of the aforedescribed embodiment the PCB 35 is connected to the boiler by an additional cable 40 which also extends through the hole 16 and connects with the boiler control mechanism 41 in a manner such that it provides to the processor 39 information as to when the boiler is at an operative mode, whether by virtue of a pre-set on period of the timer 12 or by virtue of the frost protection override 11a putting the boiler into an on mode. In this variation of the invention the processor inhibits operation of the fan and heater only when the boiler has switched to an inoperative mode and a pre-set period, typically ten minutes, has elapsed. Thus even the small amount of energy required for providing a flow of warm air through the small diameter condensate pipe is avoided for significant periods when the boiler is not in operation and creating condensate.

In accordance with a second embodiment of the present invention (see Figures 5 and 6) an icing inhibition installation 50 comprises an enclosure 51 which contains a heater, fan and temperature sensor substantially as described in respect of the first embodiment of the invention. However, in contrast to the first embodiment of the invention in which heated air is introduced into a condensate pipe at a position external of the icing inhibitor, in this embodiment of the present invention the heated air is introduced into the condensate pipe, between two sections thereof, at a position within the enclosure.

The enclosure 51 comprises a rear condensate entry port 52 and a condensate outlet port 53.

The inlet port 52 sealingly engages with a flexible connector 54 of a resilient material which is able sealingly to engage with the bore of first section of condensate pipe extending through the wall of a building against which the rear face 55 of the enclosure is mounted. The flexibility of the connector 54 accommodates any misalignment between the longitudinal axis of the inlet port 52 and the bore of the pipe which typically may extend in an inclined manner through the wall of a building, and thereby ensures that the risk of leakage of acidic condensate is minimised.

The outlet port 53 provides location for a second, outlet section 56 of the condensate pipe. This pipe has a bore of a diameter greater than that of the first, inlet section of condensate pipe into which the connector 54 locates, and in the assembly extends vertically downwards away from the enclosure 51 of the icing inhibitor device.

The upper end region 57 of the bore of the pipe section 56 extends around a condensate feed pipe 58 to define therebetween an annular plenum chamber 59 via which heated air is directed from the heater output to flow downwards through the pipe 56. The condensate feed pipe 58 is formed integrally with the body of the enclosure 51 to receive condensate from the flexible connector 54 and direct that condensate downwards, centrally through the outlet section 56 of the condensate pipe.

Preferably the inlet and outlet ports 52,53 of the enclosure are positioned such that when the inhibitor device is installed in the intended orientation the inlet and outlet ports are vertically aligned. Accordingly for a retro-fit installation in which the icing inhibitor device is to be introduced into an existing condensate pipe which extends though the wall of a building and then vertically downwards, the position at which the pipe enters or drains into a drain need not be altered.

In accordance with a third embodiment of the present invention an icing inhibitor device 60 (see Figure 7) comprises an enclosure body 61 substantially similar to the enclosure body 22 described in respect of the first embodiment of the present invention.

The device 60 of this third embodiment of the invention differs, however, in that it incorporates a built-in test module (BIT) 62. The BIT 62 is continuously powered from an external supply 63 and is communication with each of a control module 64 a heater 65 and an air flow fan 66 for monitoring the operations thereof. The control module 64 receives power from the power supply 63, receives an input signal 67 which give information regarding whether a gas boiler is in an on or off operational mode. Additionally the control module receives temperature information from sensors 68a, 68b positioned respectively at the air flow input to the heater and the air flow outlet of the heater. The control module establishes an estimate of actual ambient temperature having reference to the difference between said temperatures for a given rate of heat input from the heater. The control module sets a target temperature for the air flow at the heater outlet which is a function of the estimated ambient temperature and controls the heater to maintain the temperature of the heated air substantially constant at said target temperature.

The BIT 62 is continuously powered and continuously in operation irrespective of whether the gas boiler is in operation. The BIT operates on a weekly basis momentarily to cause the control module 64 to power the heater and fan such that the BIT is able to confirm correct operation of the heater and fan. Additionally, whenever the gas boiler is in operation the BIT continuously monitors operation of the heater and fan to confirm that they are operating in accordance with command signals 69/70.

At all times when the BIT establishes that there is correct operation or operational capability it causes a green LED 71 to illuminate. However in the event of a failure mode it causes a red LED 72 to illuminate and to flash with one of a plurality of signature sequences each indicative of a specific component failure or fault mode. Accordingly a user is informed as to whether simple re-setting of the power supply is appropriate for re-establishing correct operation of a TRIAC switch (not shown) which controls the heater 65, or whether it is necessary to arrange for a component part to be replaced or repaired.

Claims.

1. A method for inhibition of ice formation in a pipe which is exposed to a low ambient temperature comprising providing an electrically powered fan and an electrically powered heater, operating said fan and heater to provide a forced flow of heated air at a temperature above said ambient temperature and directing said forced flow of heated air through said pipe in a direction towards the pipe outlet.

2. A method according to claim 1 wherein the heater or the heater and fan is controlled in a manner that is a function of said ambient.

3. A method according to claim 1 or claim 2 wherein a measurement of said ambient temperature is employed to set a target temperature for the heated air and wherein the heater or heater and fan is controlled in a manner to maintain the temperature of heated air substantially constant.

4. A method according to claim 3 wherein the heater or the heater and fan is controlled in a manner to maintain the temperature at the air outlet of the heater substantially constant at said target temperature.

5. A method according to claim 3 wherein the heater or the heater and fan is controlled in a manner to maintain the temperature of heated air at the pipe outlet substantially constant at said target temperature.

6. A method according to any one of the preceding claims wherein said ambient temperature is an estimated ambient temperature derived from measurements of the temperature of air entering the heater and the temperature of air at the air output of the heater.

7. A method according to any one of the preceding claims wherein the fan is a constant speed fan and temperature control is achieved solely by control of the heater.

8. A method according to any one of claims 1 to 6 wherein the fan is a variable speed fan and temperature control is achieved by control of the heater and the fan speed.

9. A method according to any one of the preceding claims wherein the forced flow of air is provided only when said ambient temperature is such that water might freeze in the pipe or at the pipe outlet.

10. A method according to any one of the preceding claims wherein the pipe extends from an appliance and said air is introduced into the pipe at a position between the appliance and a distal, outlet end of the pipe.

11. A method according to claim 10 wherein said heated air is introduced into the pipe at a position within an enclosure that contains means for providing at least one of the method steps of heating air and of creating a forced flow of air.

12. A method according to any one of the preceding claims wherein the pipe extends through the external wall of a building to drain externally and wherein air is taken from the external environment, heated, and the forced into the pipe at a position which lies external of the building.

13. A method according to any one of the preceding claims wherein the pipe extends from an appliance which emits condensate which is drained via said pipe, said appliance being under the control of means which determines whether the appliance is to be in an operative mode or an inoperative mode and confining said forced flow of air to periods when the appliance is in an operative mode or to said periods each extended by an additional period.

14. An icing inhibitor for inhibiting formation of ice in a pipe comprising an enclosure having an air inlet port and an air outlet for communication with a pipe, the enclosure containing an electrically powered fan for inducing air to flow into the enclosure through the air inlet port, and an electrically powered heater element, said icing inhibitor having associated therewith a heater control module whereby, in use with a temperature sensor which measures the temperature of heated air, the control module is operable to control the electrical power to the heater as a function of said temperature of heated air.

15. An icing inhibitor according to claim 14 wherein said temperature sensor is within the enclosure and positioned to measure the temperature of heated air at the air outlet of the heater.

16. An icing inhibitor according to claim 14 wherein said temperature sensor is positioned remote from the enclosure and measures the temperature of heated air at the pipe outlet.

17. An icing inhibitor according to any one of claims 14 to 16 wherein the control module is operable to control the temperature of heated air to be at a target temperature which is a function of the ambient or an estimate of the ambient temperature external of the enclosure.

18. An icing inhibitor according to any one of claims 14 to 17 wherein air is introduced into the pipe or a junction between two sections of pipe at a position within the icing inhibitor enclosure.

19. An icing inhibitor for inhibiting formation of ice in a pipe such as a condensate pipe and comprising an electrically powered fan, an electrically powered heater and a control module to receive temperature information and control operation of the fan and heater as a function of received temperature information whereby in use the icing inhibitor is operable to provide a flow of heated air for inhibiting formation of ice in a pipe, said icing inhibitor further comprising a built-in test (BIT) facility operable in at least one of a one-off, intermittent and continuous mode to provide a BIT output indicative of

whether or not a fault condition exists in respect of operation of at least said heater and fan.

20. An icing inhibitor according to claim 19 wherein the output of the BIT facility is audible and/or visual.

21. An icing inhibitor according to claim 19 or claim 20 wherein the BIT facility provides a non-audible and non-visual signal for transmission to a location remote from the icing inhibitor for providing an audible or visual output at said remote location.

22. An icing inhibitor according to any one of claims 19 to 21 wherein the BIT facility is operable to distinguish between different fault conditions and is operable to provide an output having a characteristic which may be specifically associated with a particular fault condition.

23. An icing inhibitor according to any one of claims 19 to 22 wherein the BIT facility provides an output indicative of whether or not a fault condition exits in at least one of a temperature sensor and said control module.

24. An icing inhibitor according to any one of claims 19 to 23 wherein the BIT facility is operable to cause the icing inhibitor to operate in a reversionary mode when one or more specific functions of the icing inhibitor are established as being defective.

25. An icing inhibitor according to any one of claims 19 to 24 wherein the heater is under the control of a TRIAC type switch and the BIT output is operable to provide an output indicative of a need to disconnect and then re-establish the power supply to at least a part of the icing inhibitor.

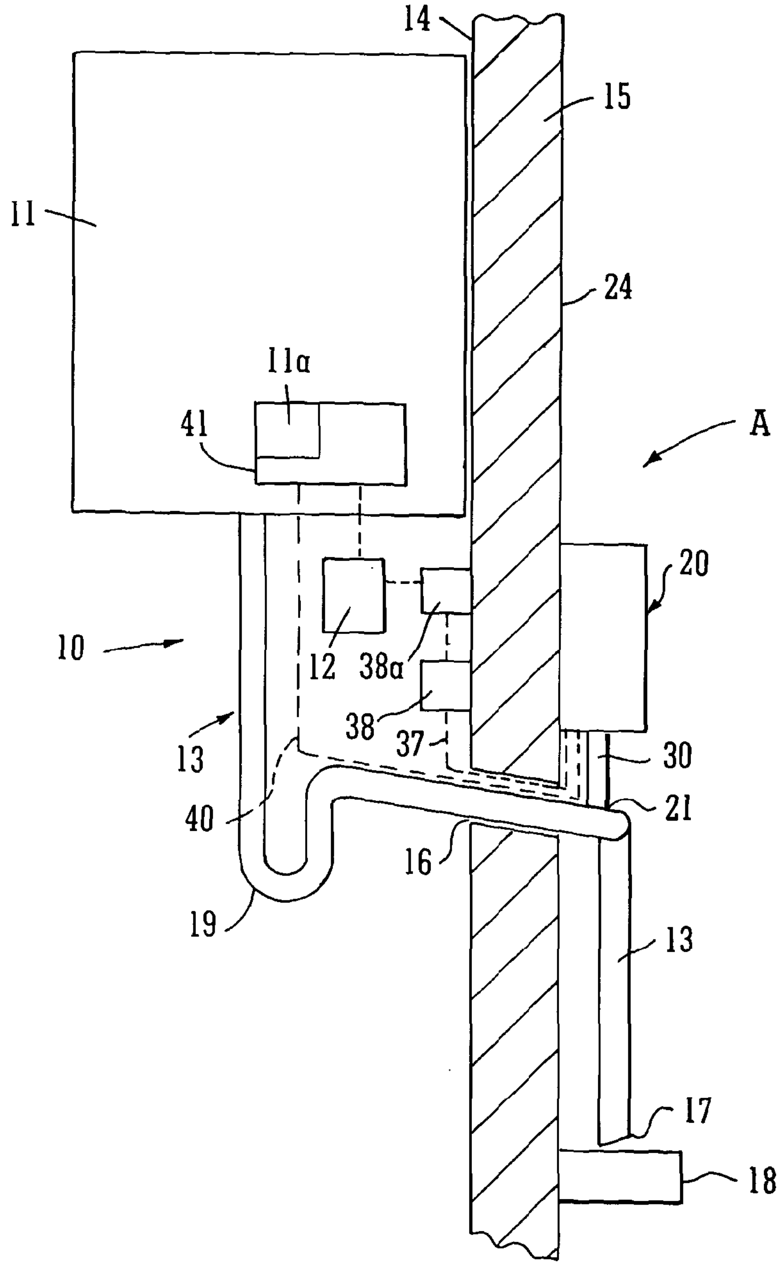

FIG. 1

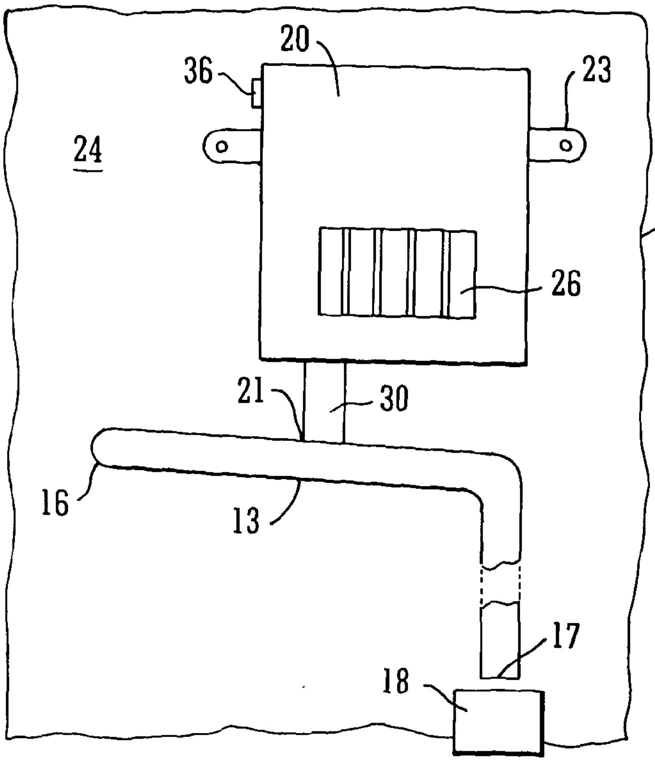

FIG. 2

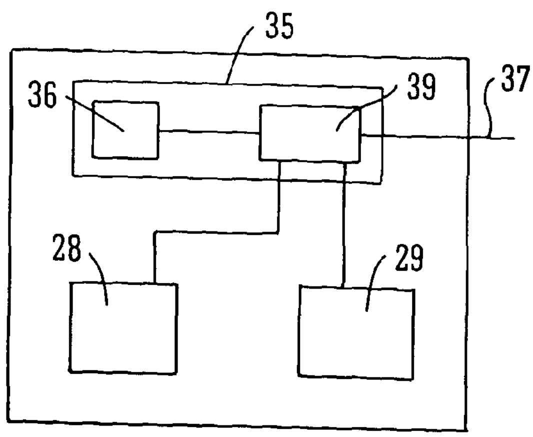

FIG. 4

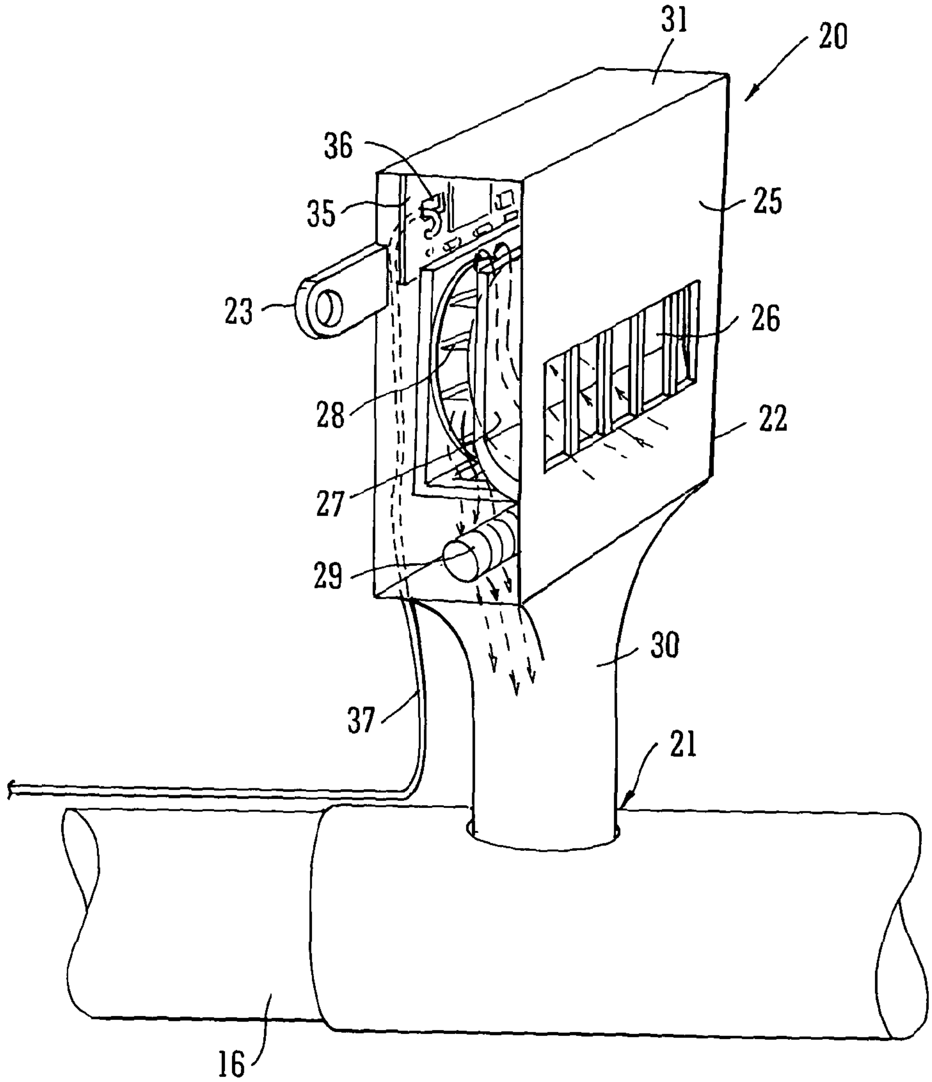

FIG. 3

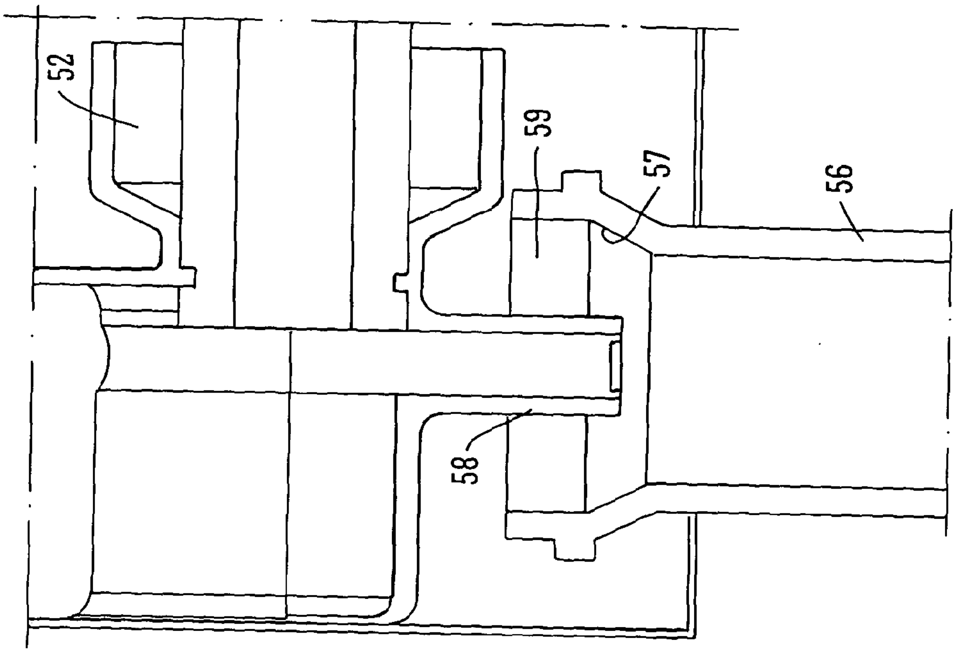

FIG. 6

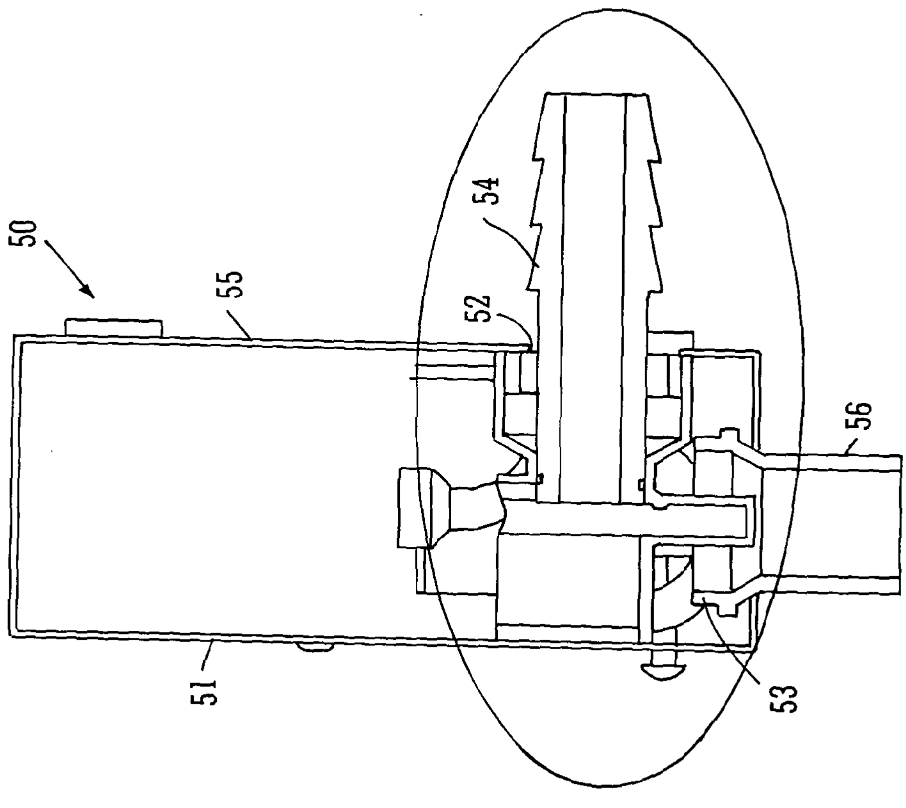

FIG. 5

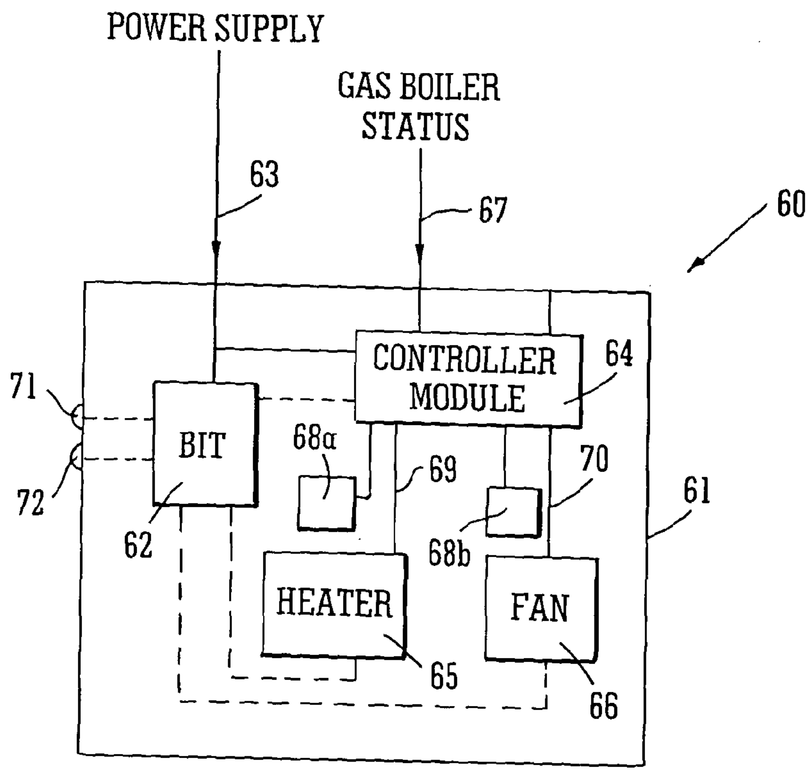
POWER SUPPLY
GAS BOILER STATUS
63
67
60
CONTROLLER MODULE
64
71
BIT
68a
69
70
61
72
62
68b
HEATER
FAN
65
66

FIG. 7