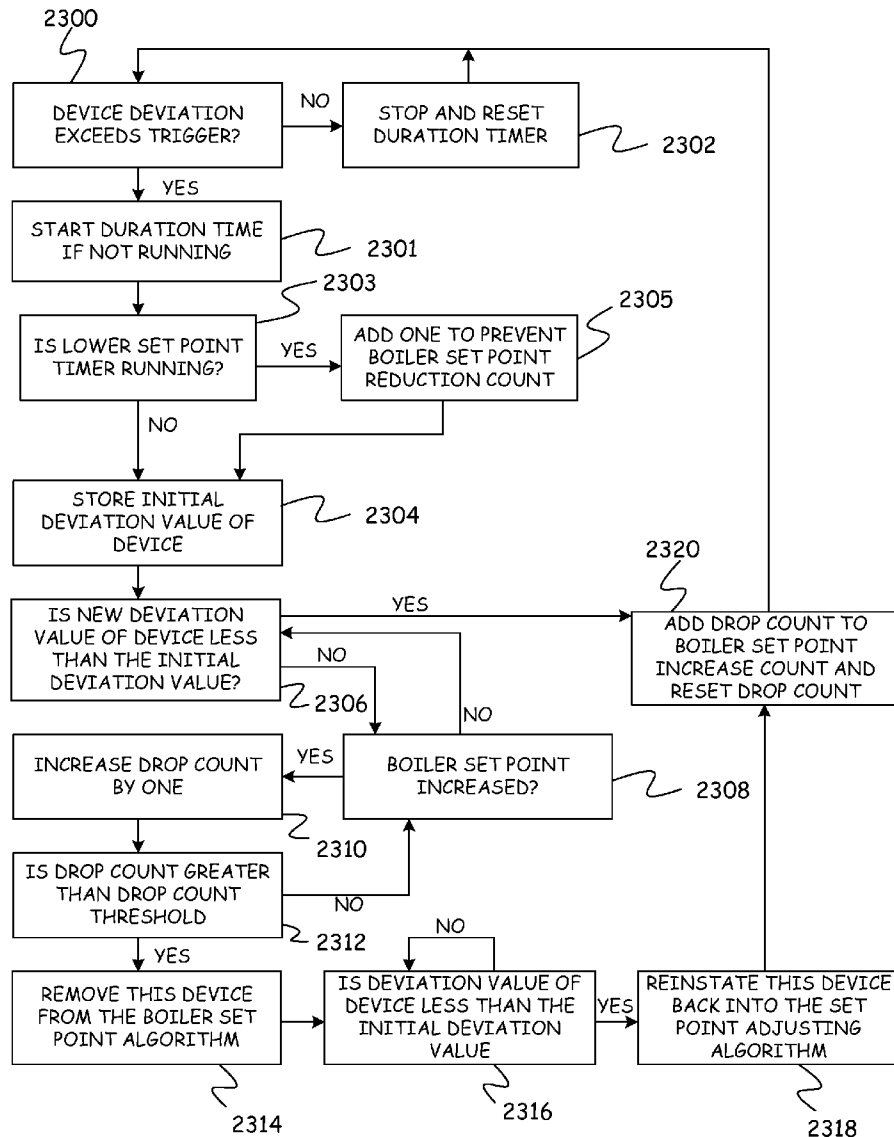




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(19) **United States**(12) **Patent Application Publication**
Evans et al.(10) **Pub. No.: US 2015/0204580 A1**(43) **Pub. Date: Jul. 23, 2015**(54) **CONTROL SYSTEM FOR OPTIMIZING
BOILER FLUID TEMPERATURE SET POINTS****Publication Classification**(71) Applicant: **Blesi-Evans Company**, Minneapolis,
MN (US)(72) Inventors: **Mark Edward Evans**, Edina, MN (US);
John Louis Honeck, JR., Rochester,
MN (US)(51) **Int. Cl.**
F24H 8/00 (2006.01)
F24H 9/20 (2006.01)(52) **U.S. Cl.**
CPC **F24H 8/006** (2013.01); **F24H 9/2007**
(2013.01)(21) Appl. No.: **14/598,848**(22) Filed: **Jan. 16, 2015****Related U.S. Application Data**(60) Provisional application No. 61/928,698, filed on Jan.
17, 2014.(57) **ABSTRACT**

A system for establishing a boiler fluid set point includes a plurality of input devices providing input values for a plurality of different portions of a heating system and a controller determining that during a period of time there was always at least one input value that deviated from a set point for the input value by more than a threshold amount and in response, the controller increasing the boiler fluid set point.



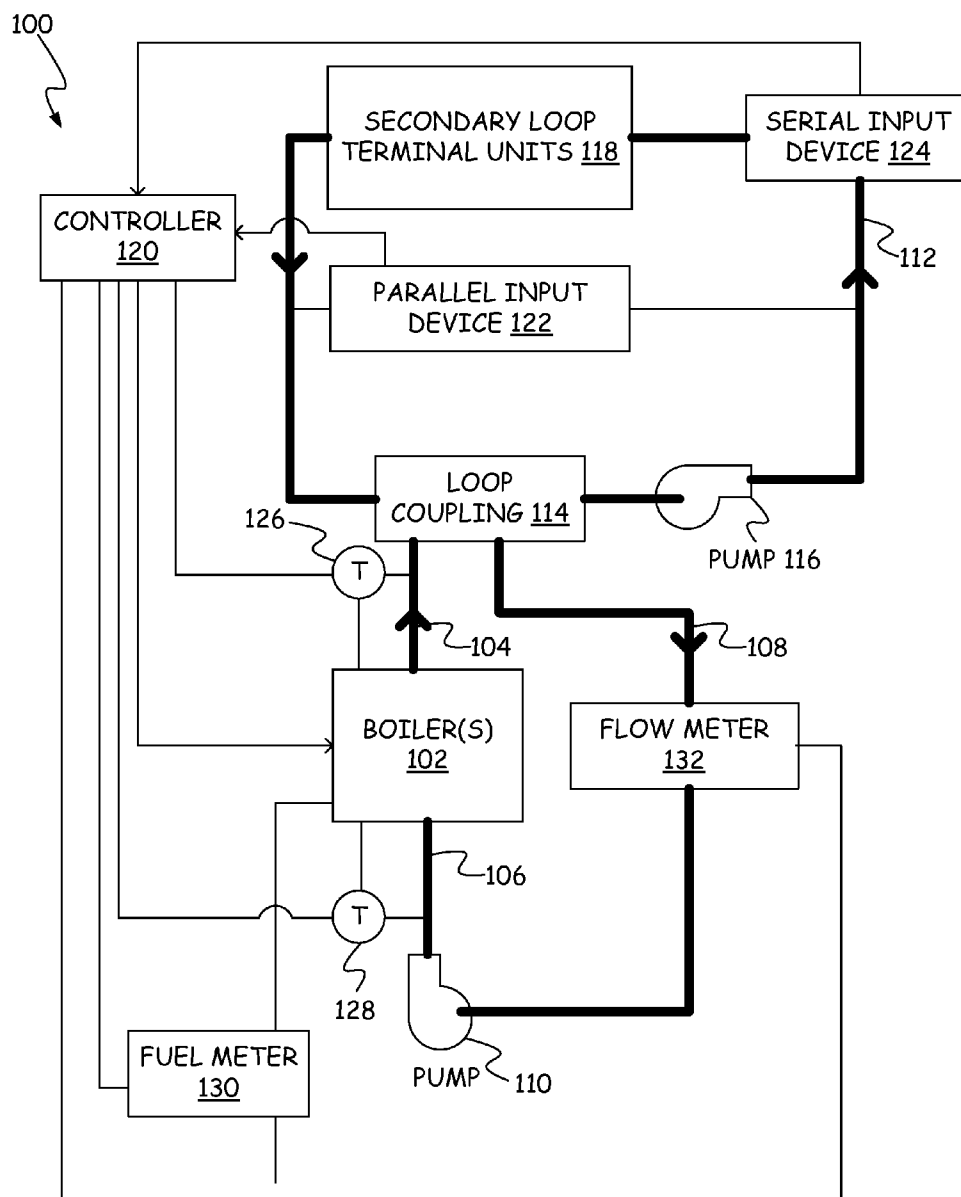


FIG. 1

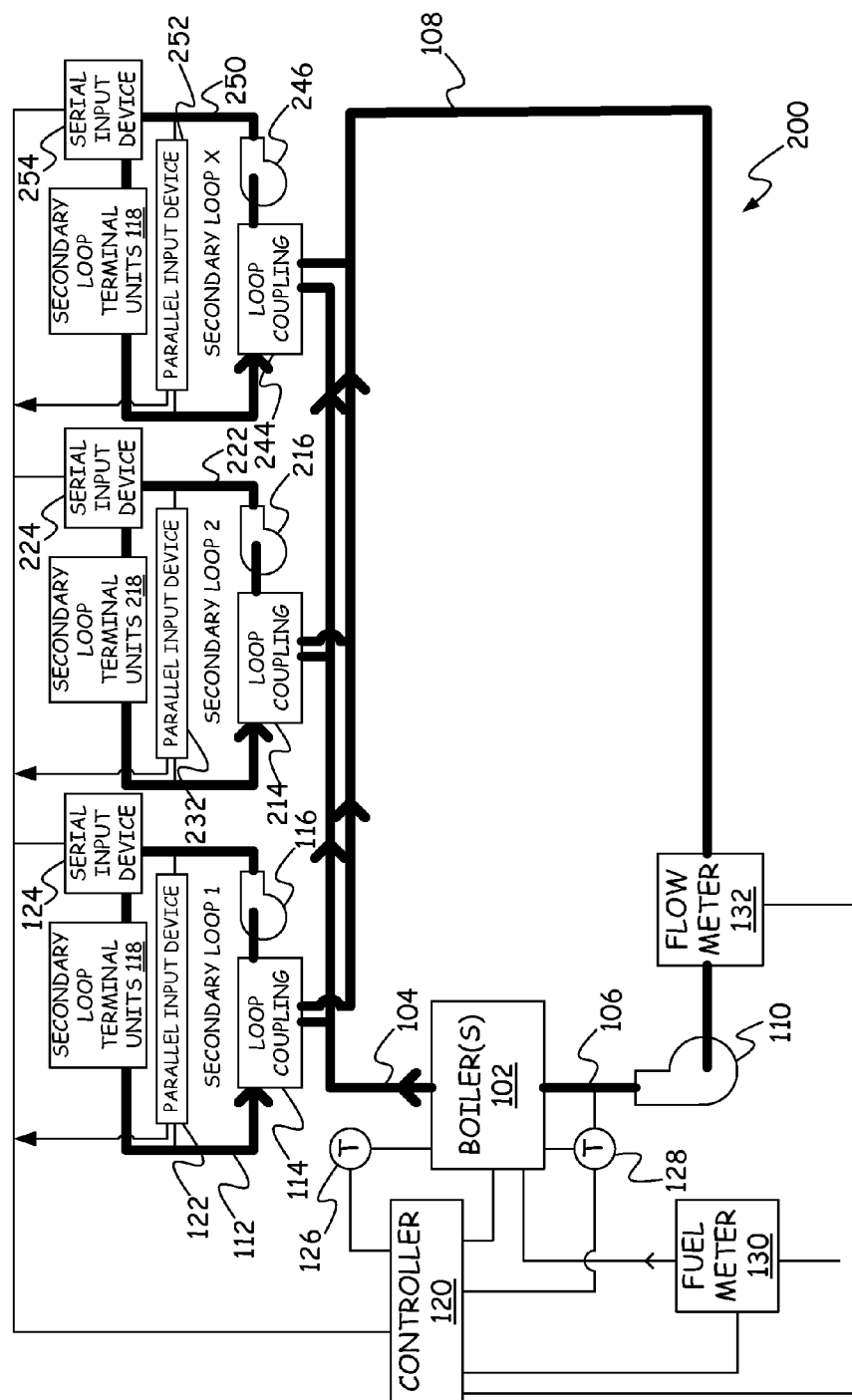


FIG. 2

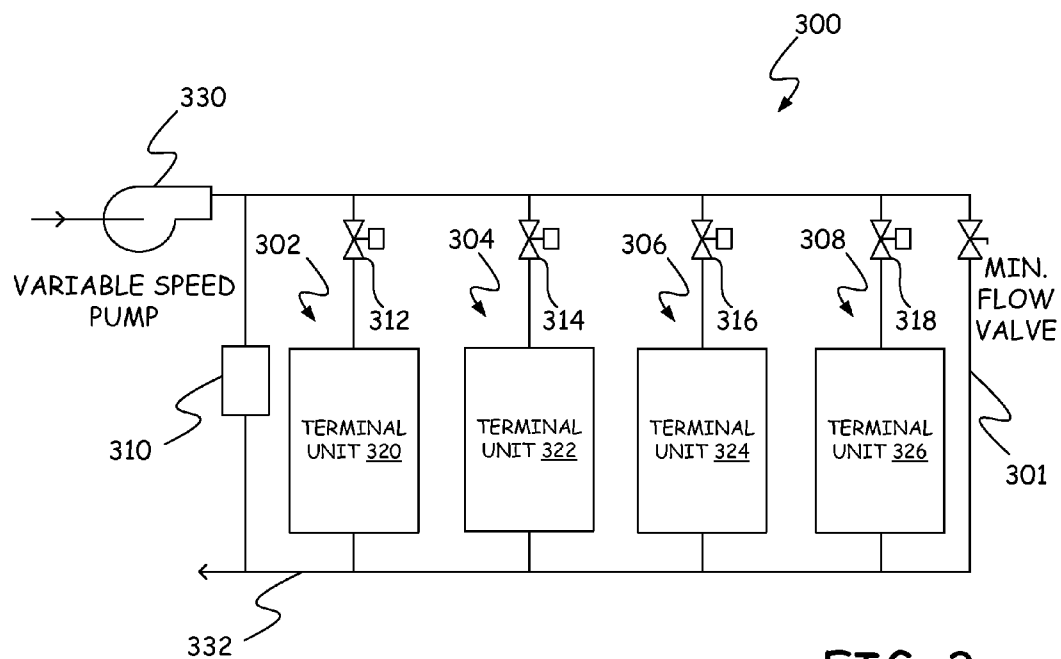


FIG. 3

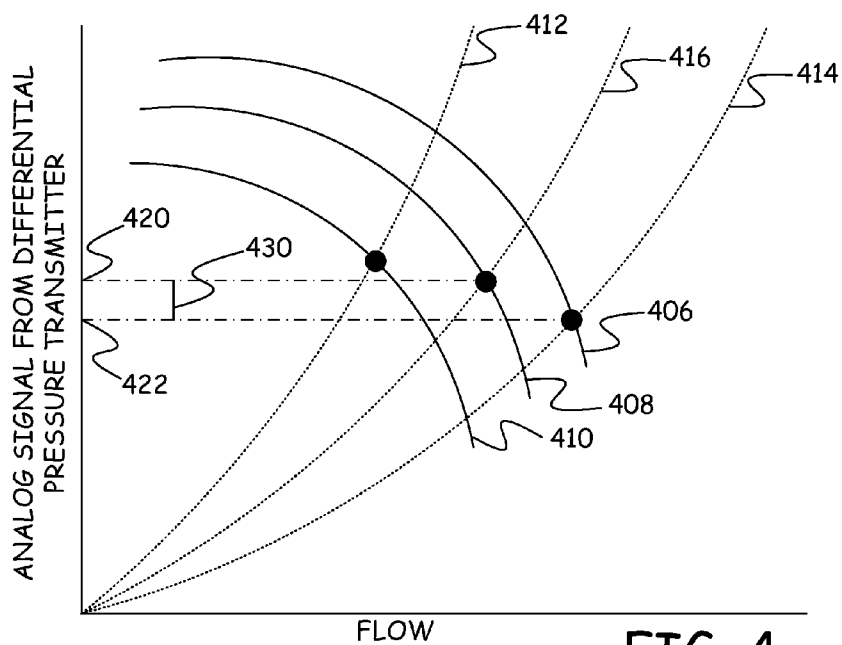


FIG. 4

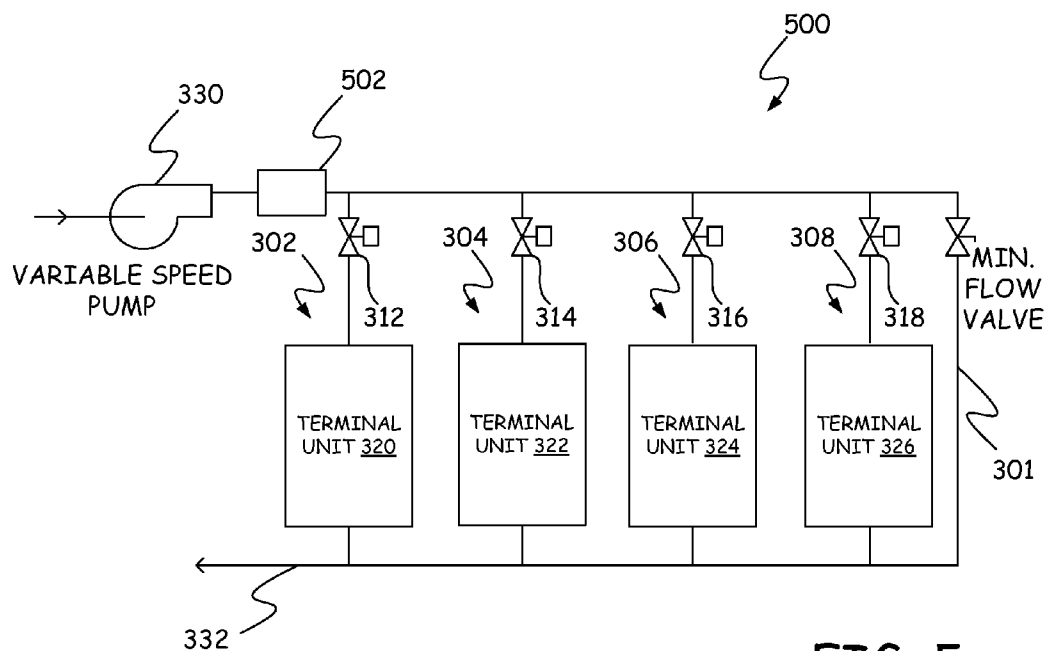


FIG. 5

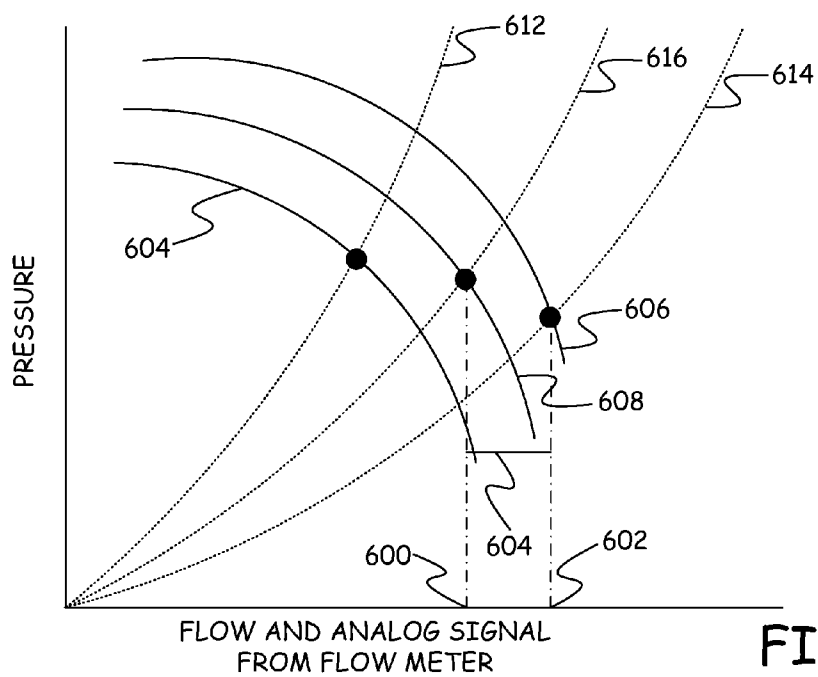


FIG. 6

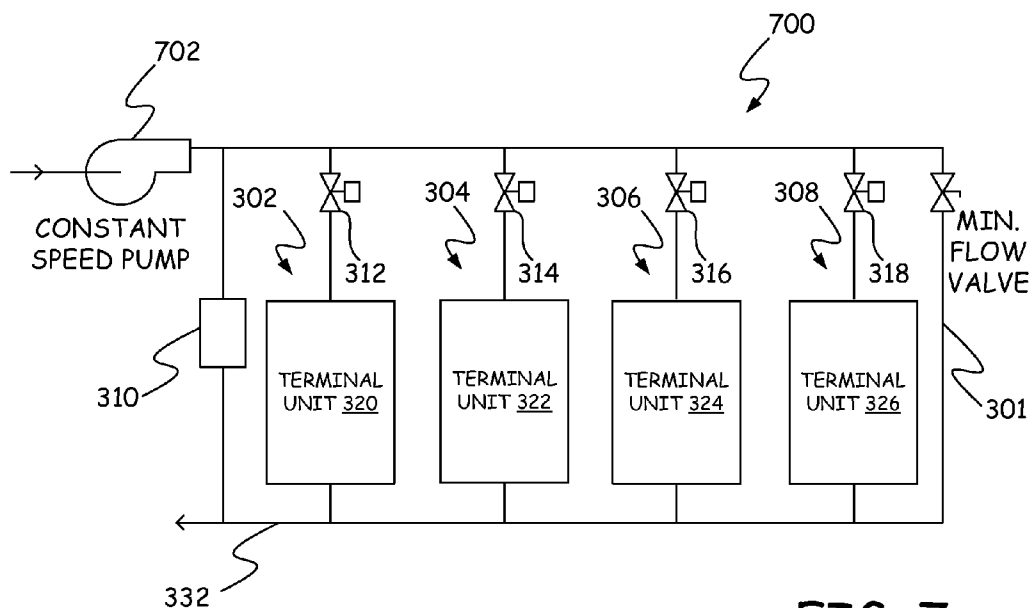


FIG. 7

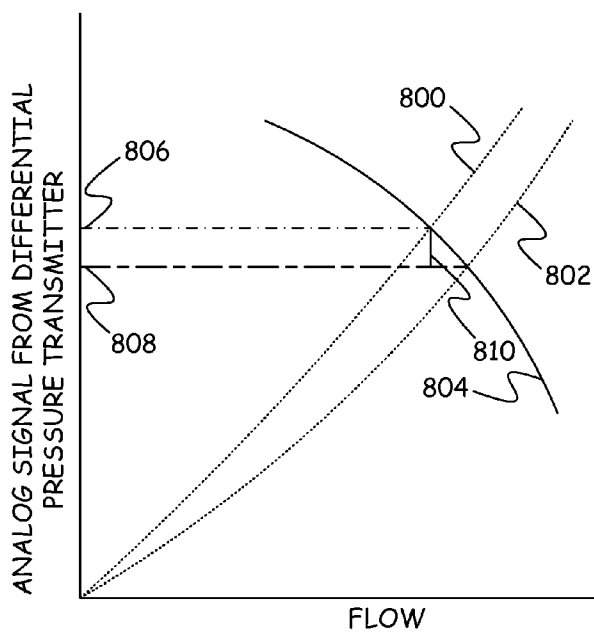


FIG. 8

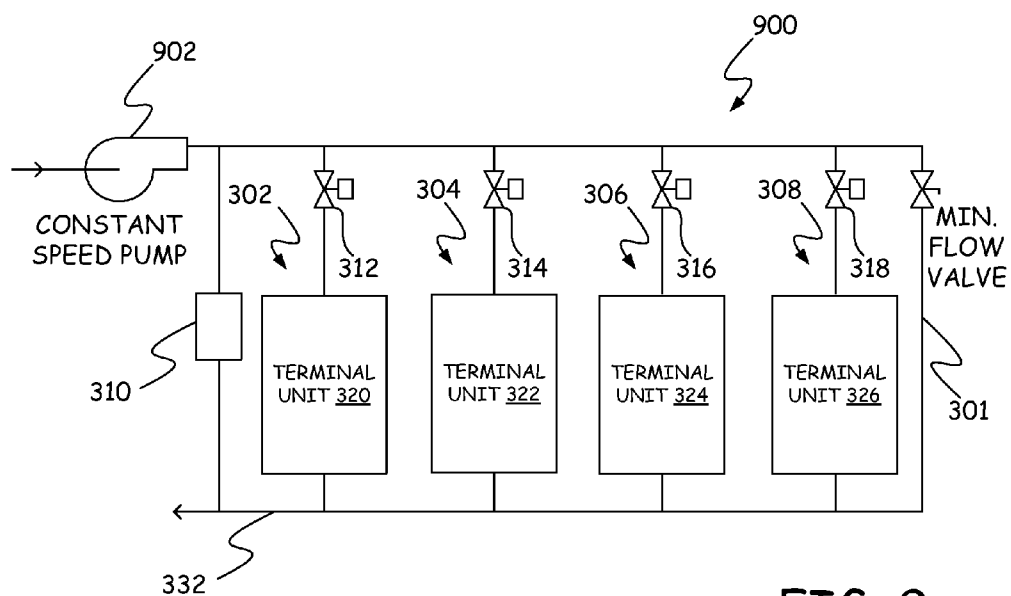


FIG. 9

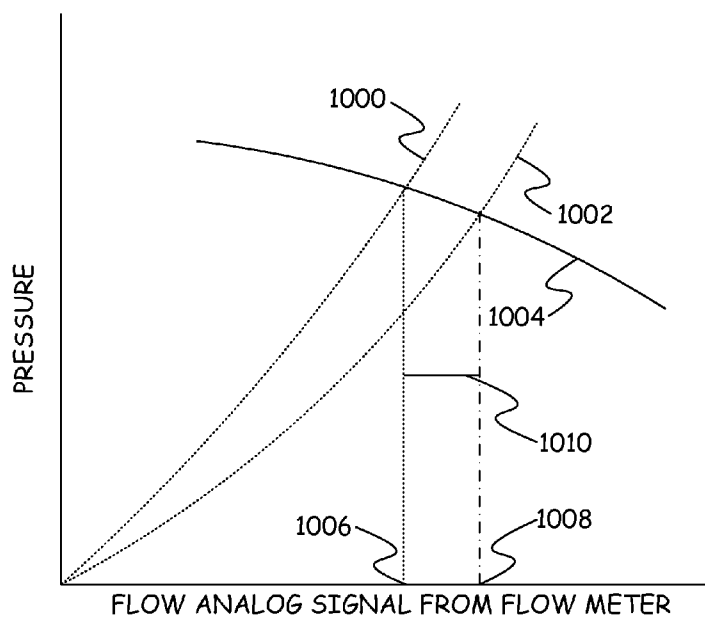


FIG. 10

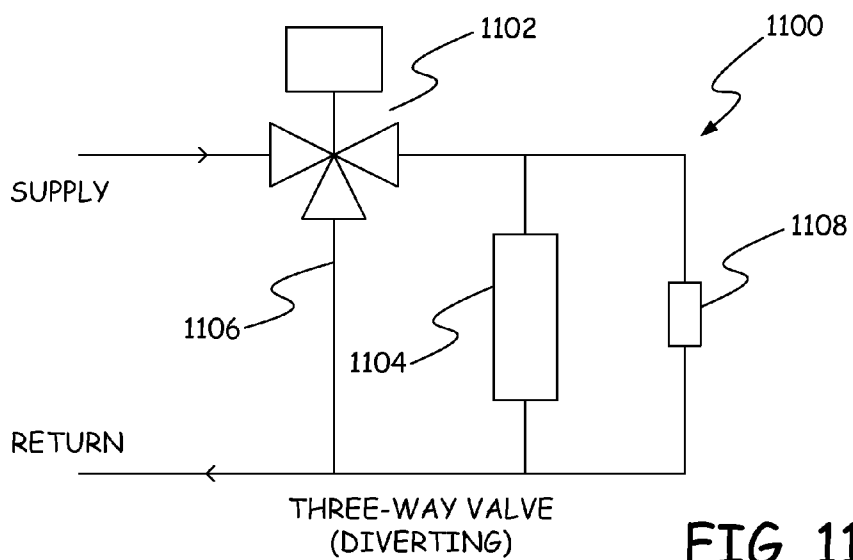


FIG. 11

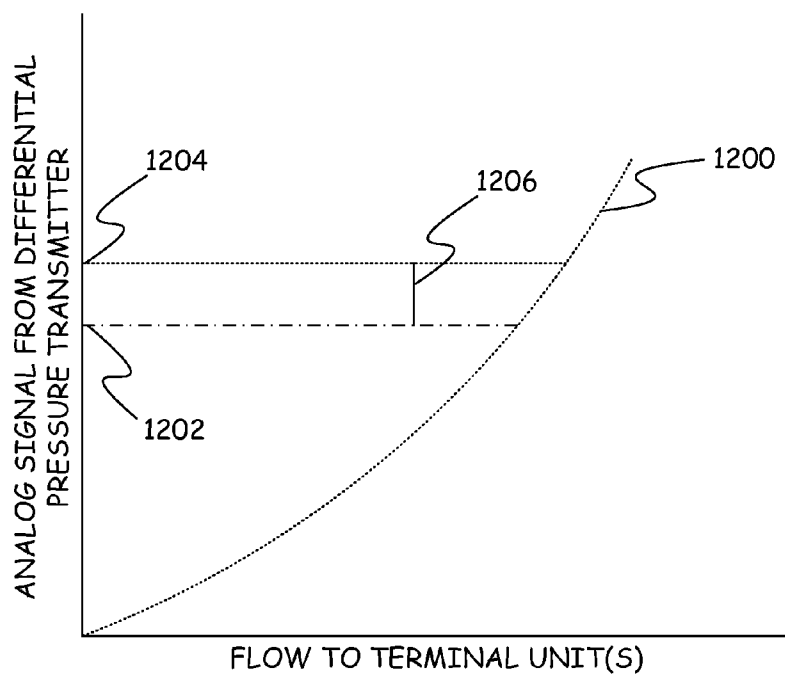


FIG. 12

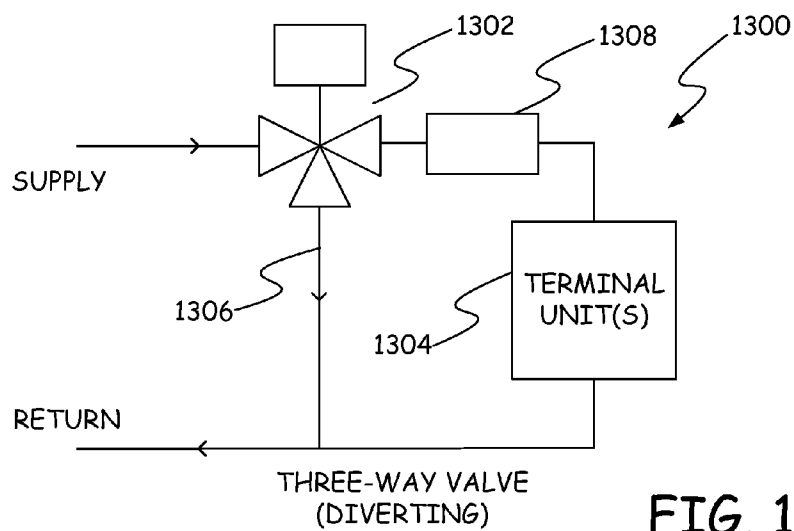


FIG. 13

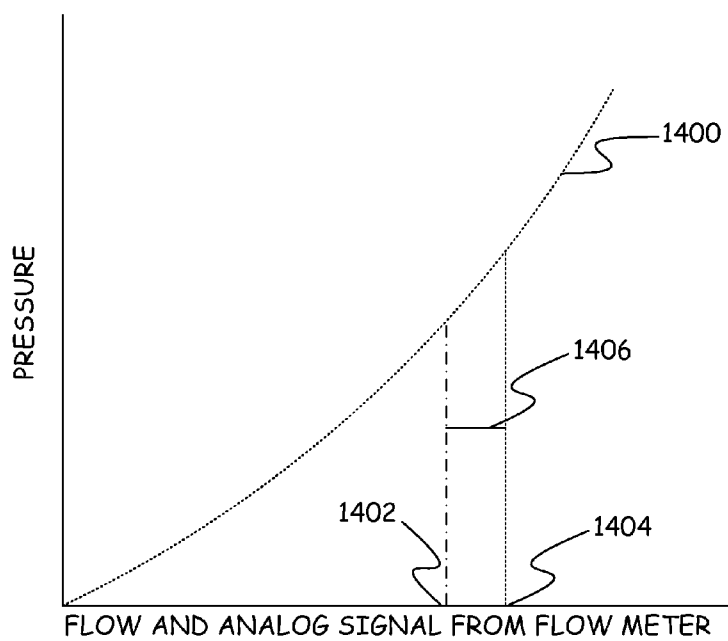


FIG. 14

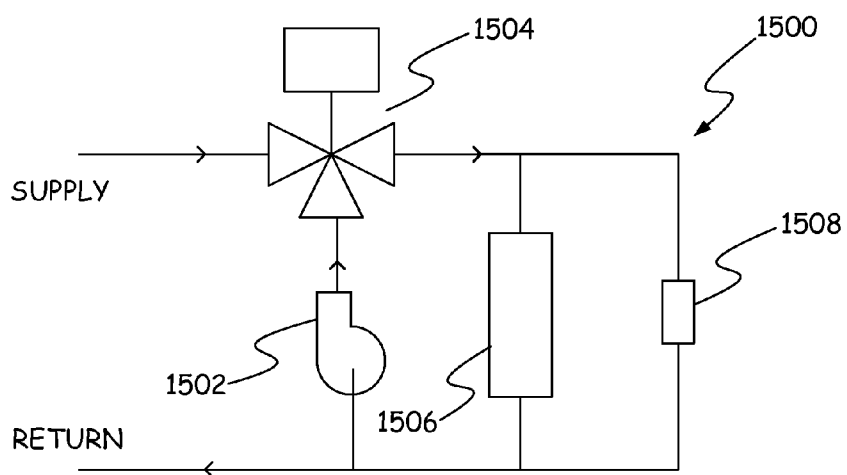


FIG. 15

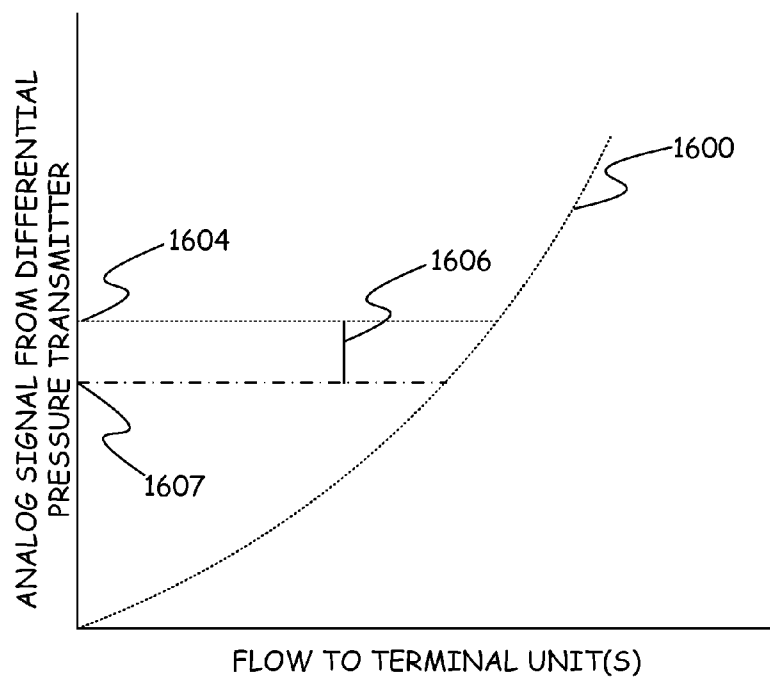


FIG. 16

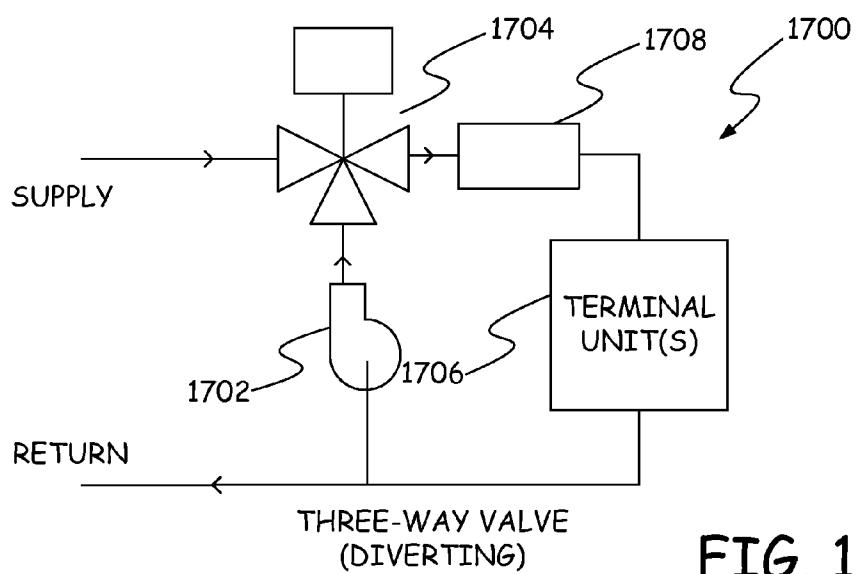


FIG. 17

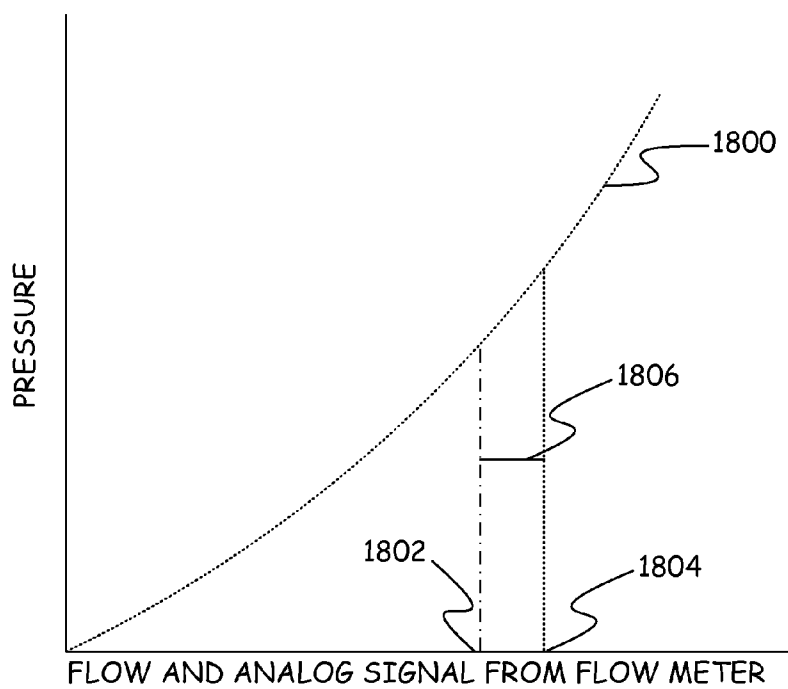


FIG. 18

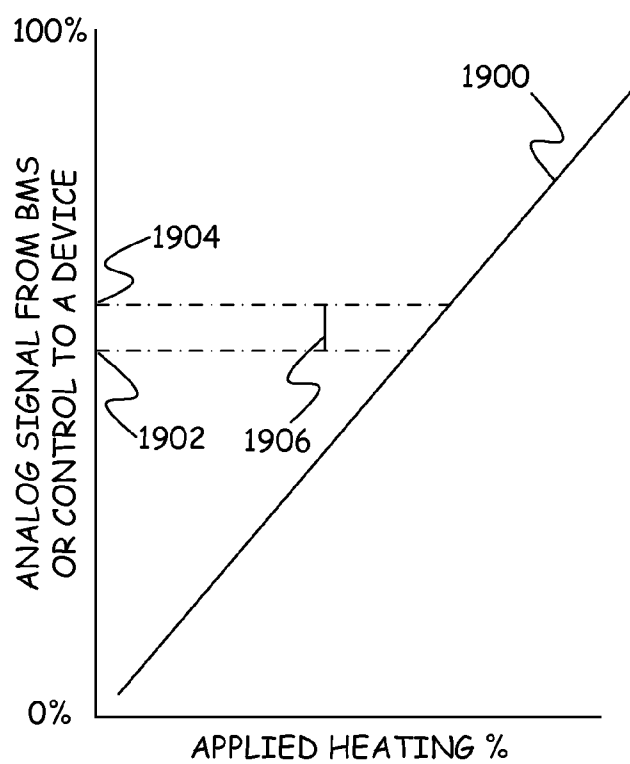


FIG. 19

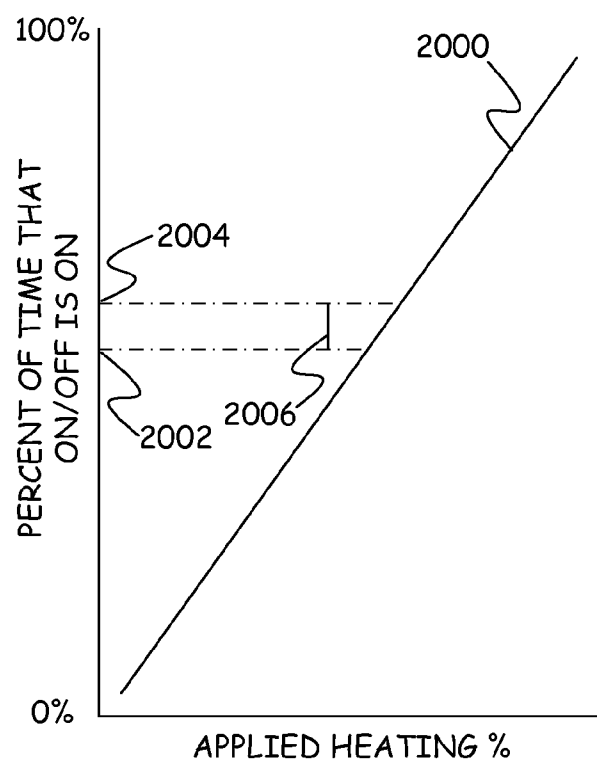


FIG. 20

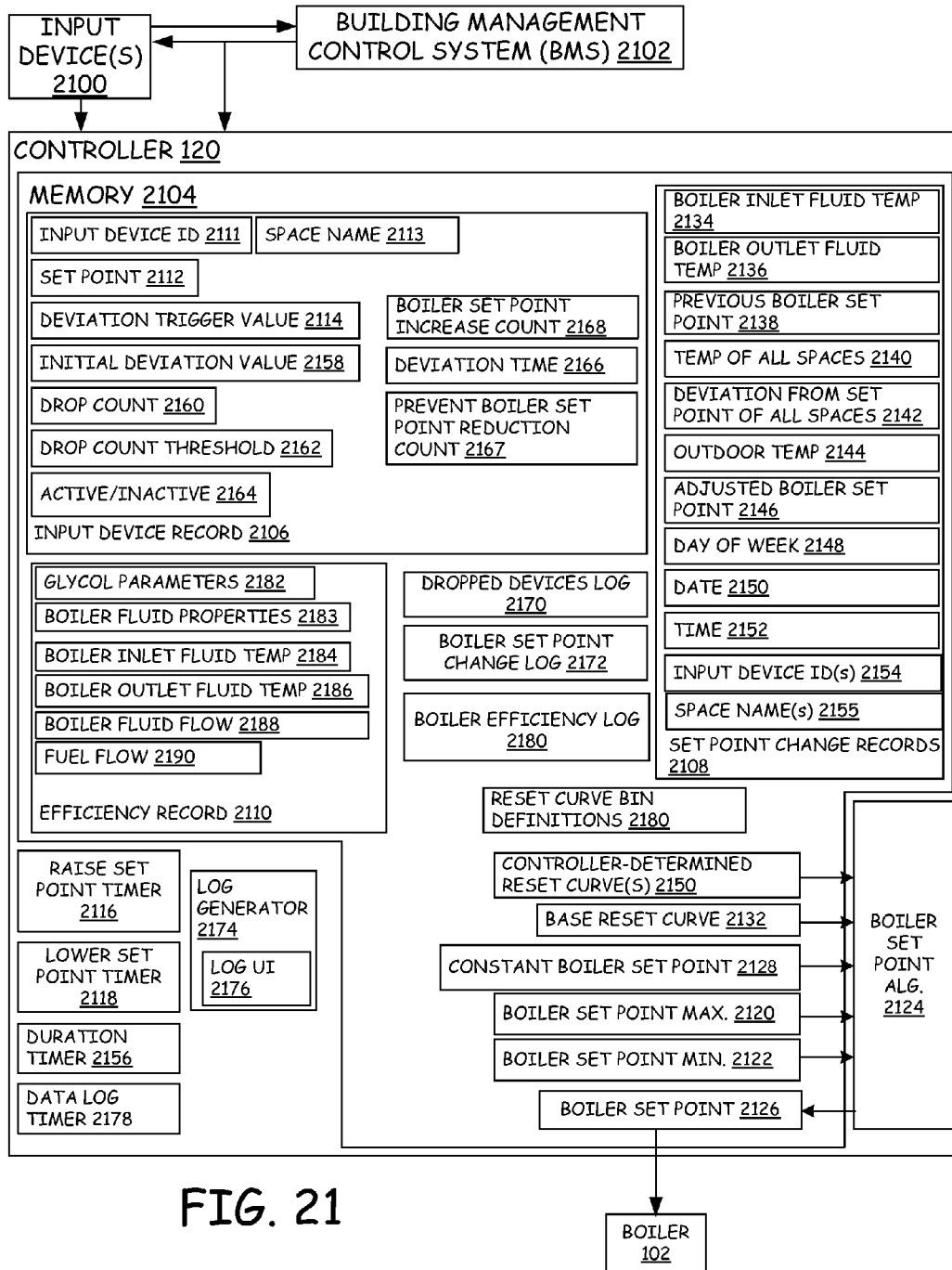


FIG. 21

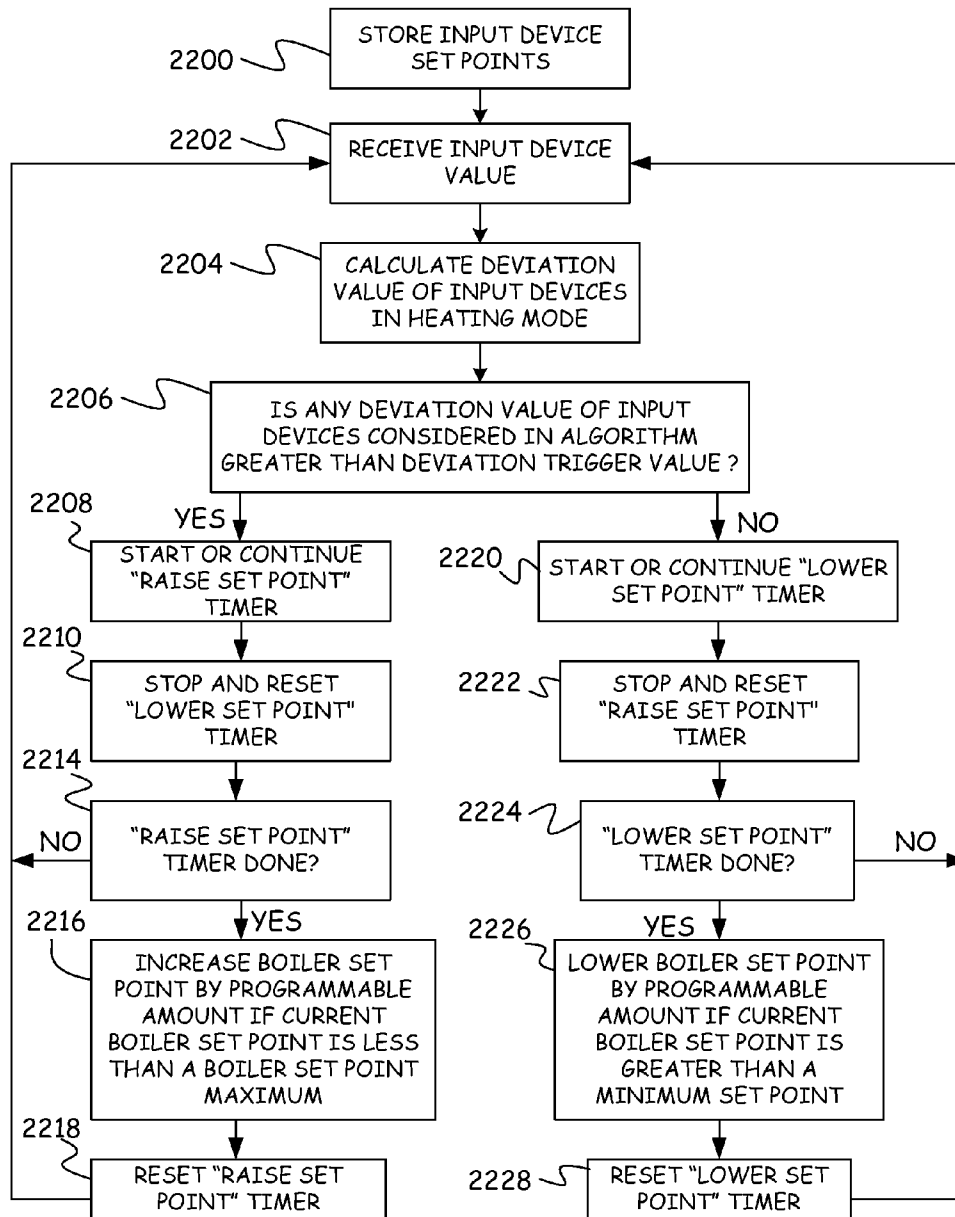


FIG. 22

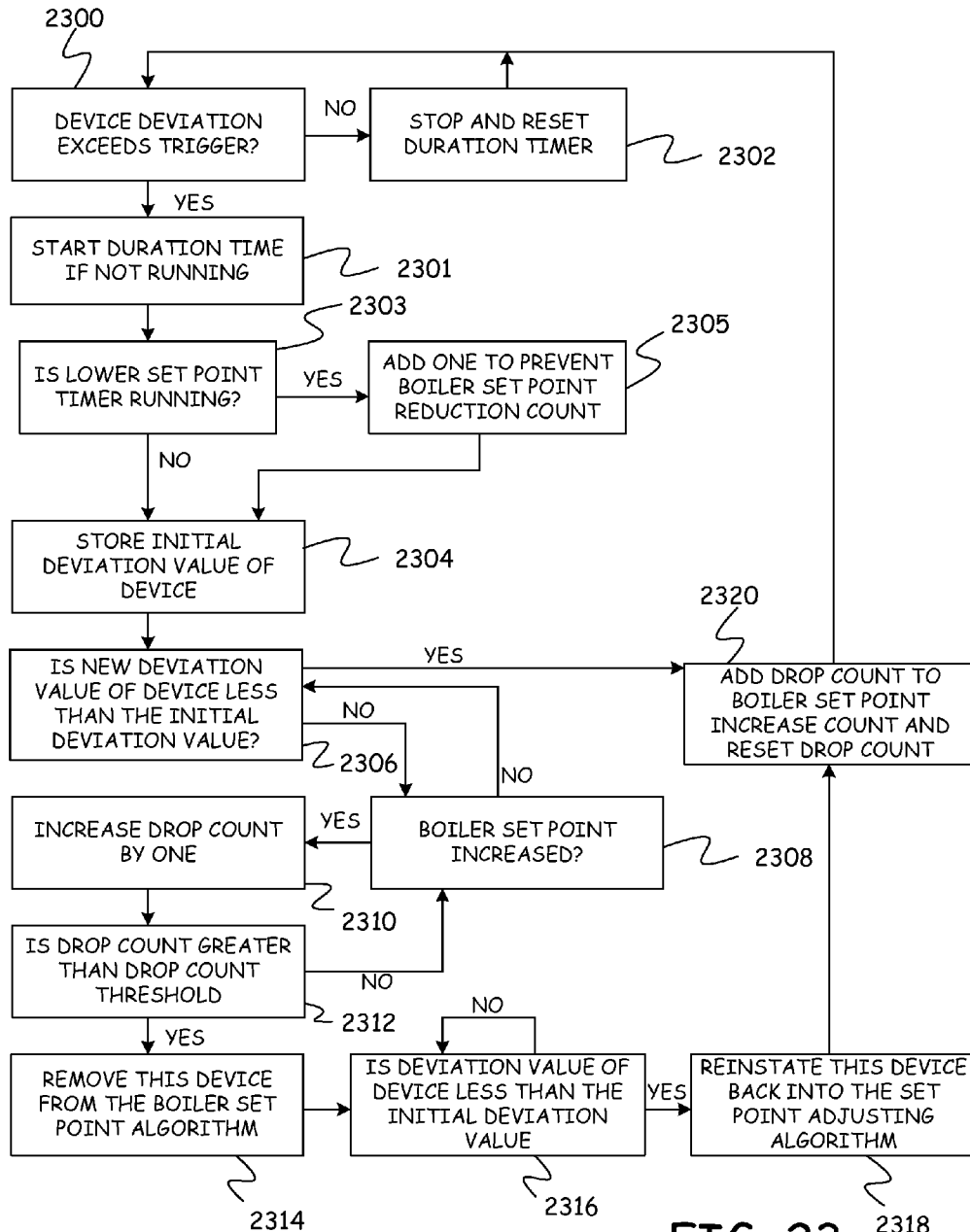


FIG. 23

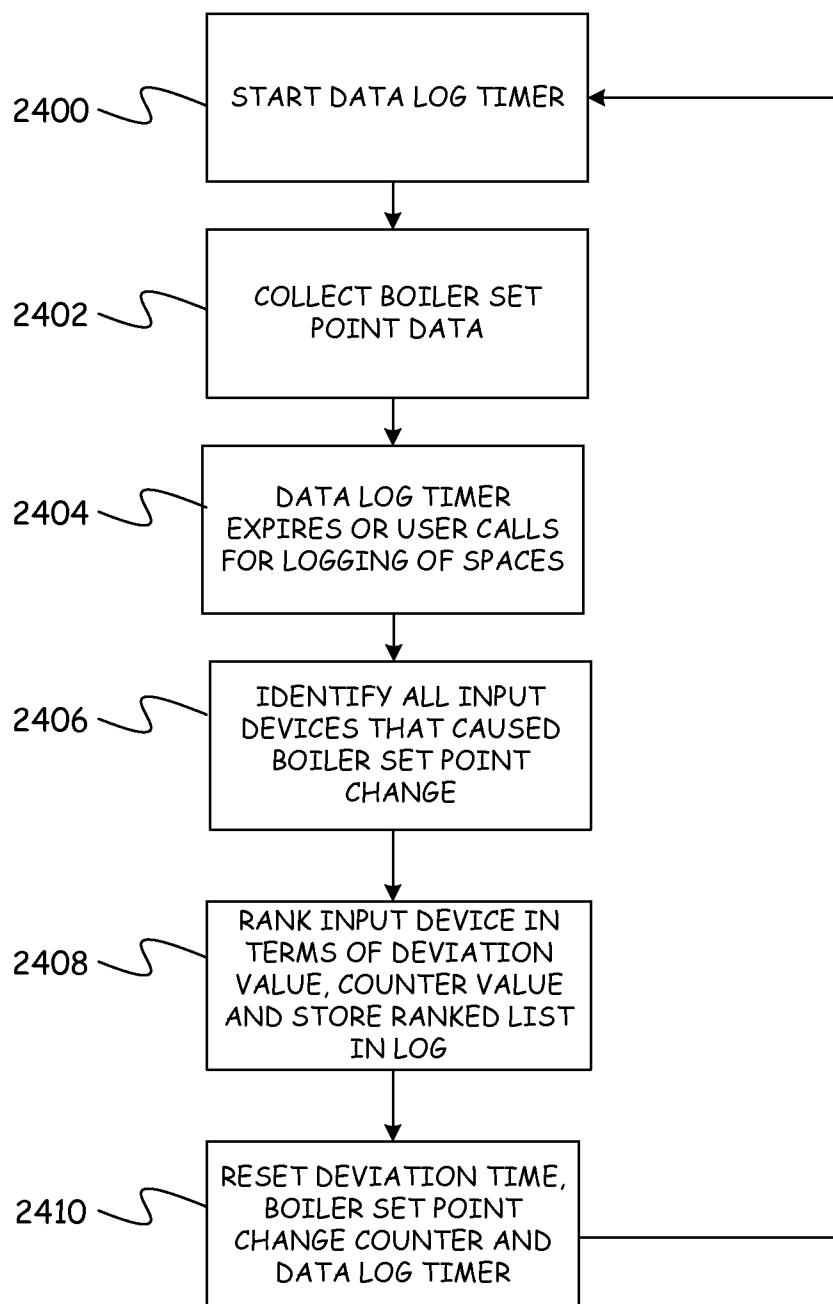
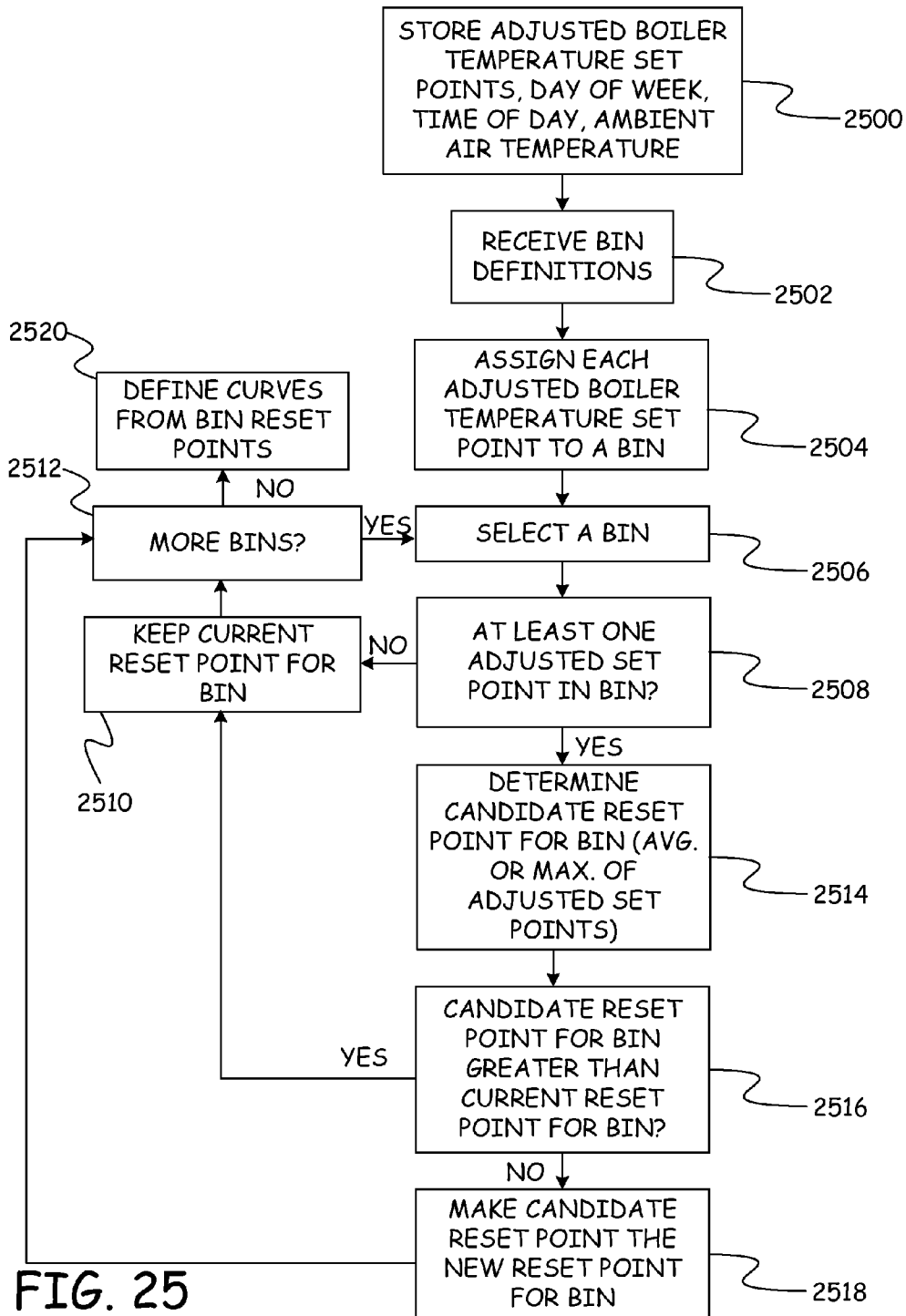


FIG. 24



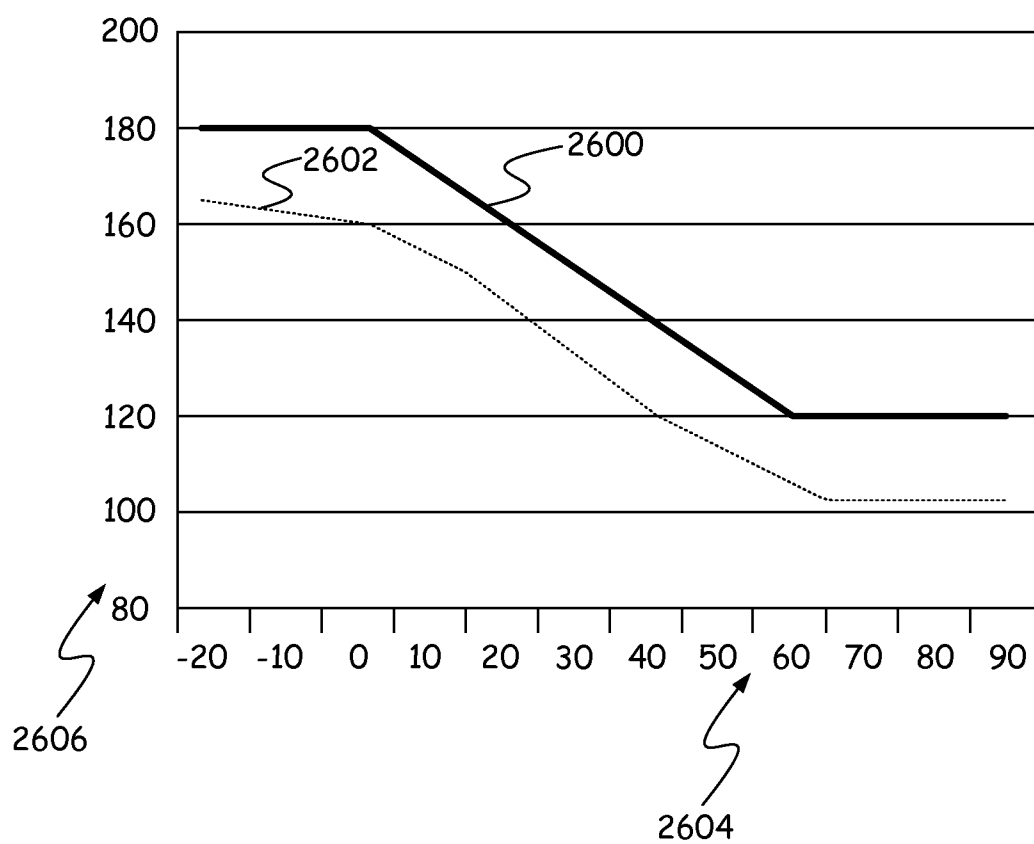


FIG. 26

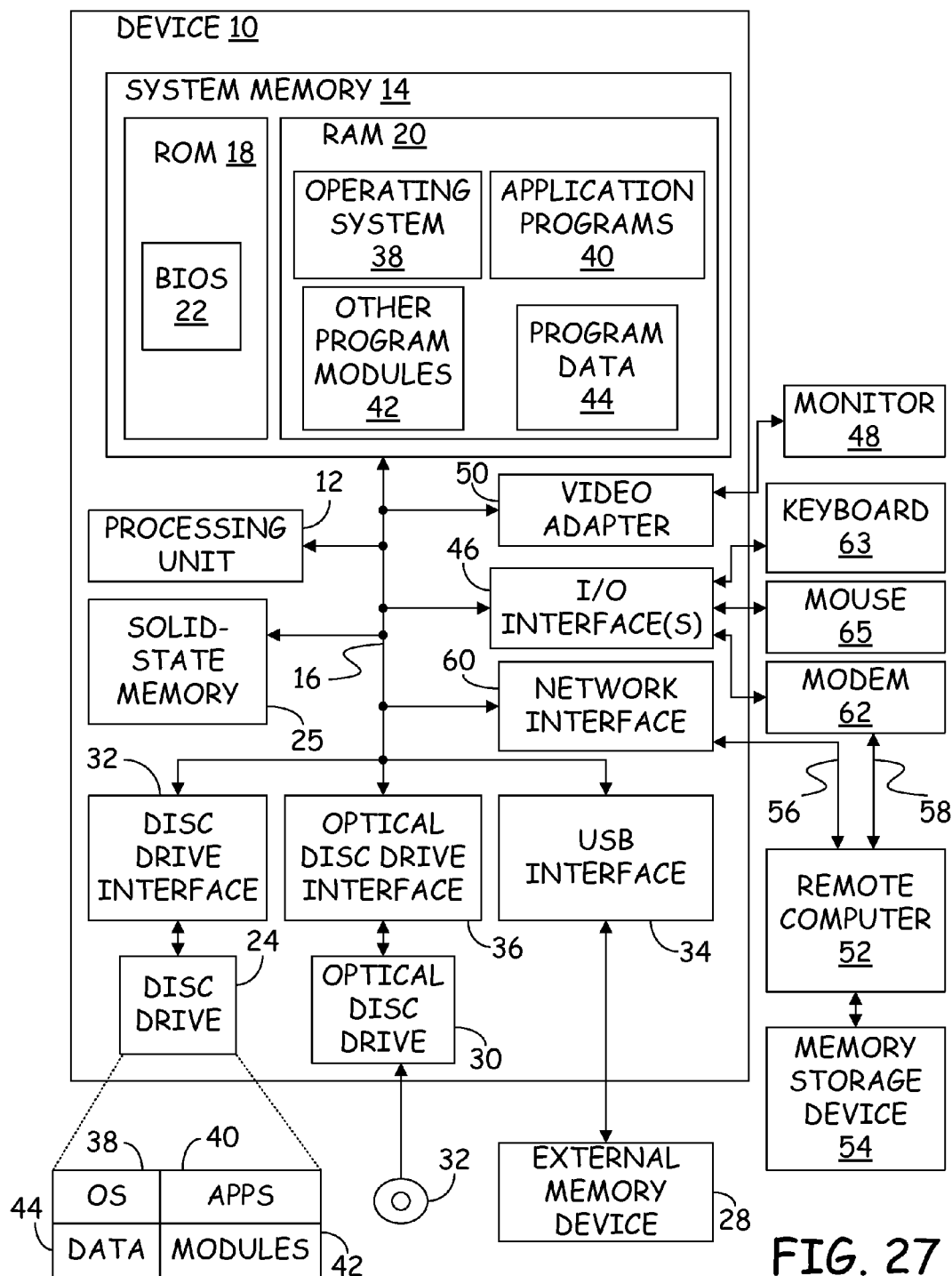


FIG. 27

CONTROL SYSTEM FOR OPTIMIZING BOILER FLUID TEMPERATURE SET POINTS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application is based on and claims the benefit of U.S. provisional patent application Ser. No. 61/928,698, filed Jan. 17, 2014, the content of which is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] The operating efficiency of a condensing type boiler is dependent upon the fluid flow rate and fluid temperatures into and out of the boiler. A percentage of the flue gas resulting from burning fuel contains water vapor. The water vapor contains some sensible and latent heat or latent energy. Each pound of fluid vapor that is condensed in the boiler(s) or a condensing economizer associated with the boiler(s) adds roughly 1000 BTU's to the hydronic system and thereby lowers the amount of fuel that is required to maintain the boiler's operational temperature set point.

[0003] The amount of vapor condensed is related to the dew point of the flue gas and the temperature difference between the fluid temperatures in the boiler, particularly the colder inlet fluid, and the dew point of the flue gas. The greater the fluid temperatures are below the combustion gas dew point, the greater is the amount of condensate produced. The boiler fluid temperature set point, also referred to simply as the set point or boiler fluid set point, that provides the highest amount of condensate, and the highest boiler system efficiency, is that set point which provides the lowest possible boiler fluid temperature at the output of the boiler that is sufficiently high enough to main the proper air temperature in each space of the facility being heated.

[0004] The terminal units, the devices that put heat into heated spaces, need a certain minimum temperature in order to accomplish their purpose of adding sufficient heat to a given space to provide the desired temperature in the space. The desired temperature, or set point, in the space is established by a thermostat or control with a temperature sensor in the individual space. In a hydronic heating system, there can be one or multiple thermostats, each with a common or unique set point.

[0005] The heating fluid piping in a hydronic heating system can be installed in several ways. One way is to have all of the fluid in the system flow through the boiler or boilers. Another way is to use primary and secondary piping. The boilers are installed in the primary loop and provide heat to one or more secondary loops. Terminal heating units are installed in the secondary loops. Each secondary loop can have the same or unique set points. The primary loop temperature set point, identical to the boiler fluid set point, can be varied as well.

[0006] The boiler fluid set point can be established either manually or automatically. A commonly used automatic method is generally called outdoor reset in which a linear curve of set points is established at various outdoor ambient temperatures. Since terminal units are required to release more heat when the ambient is colder, the boiler fluid set point is raised in proportion to falling ambient (outdoor) temperatures in accordance to the established curve of set points.

SUMMARY

[0007] A system for establishing a boiler fluid set point includes a plurality of input devices providing input values for a plurality of different portions of a heating system and a controller determining that during a period of time there was always at least one input value that deviated from a set point for the input value by more than a threshold amount and in response, the controller increasing the boiler fluid set point.

[0008] A controller in a heating system changes a boiler fluid set point, stores the changed boiler fluid set point together with an outside temperature and uses the stored changed boiler fluid set point and the stored outside temperature to generate a reset curve used to establish a boiler fluid set point when starting a boiler system.

[0009] A controller in a heating system identifies input devices that prevent the controller from lowering a boiler fluid set point and generates a log providing a list of such input devices.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 provides a simplified block diagram of a facility in accordance with some embodiments.

[0011] FIG. 2: provides a simplified block diagram of a facility in accordance with further embodiments.

[0012] FIG. 3 provides a block diagram of a portion of a facility with a parallel input device in accordance with a third embodiment.

[0013] FIG. 4 provides pump curves and system graphs showing the relationships between flow and differential pressure for the embodiment of FIG. 3.

[0014] FIG. 5 provides a block diagram of a portion of a facility with a serial input device in accordance with a fourth embodiment.

[0015] FIG. 6 provides pump curves and system graphs showing the relationships between flow and differential pressure for the embodiment of FIG. 5.

[0016] FIG. 7 shows a block diagram of a portion of a facility with a parallel input device and a constant speed pump in accordance with a fifth embodiment.

[0017] FIG. 8 provides pump curves and system graphs showing the relationships between flow and differential pressure for the embodiment of FIG. 7.

[0018] FIG. 9 shows a block diagram of a portion of a facility with a serial input device and a constant speed pump in accordance with a sixth embodiment.

[0019] FIG. 10 provides pump curves and system graphs showing the relationships between flow and differential pressure for the embodiment of FIG. 9.

[0020] FIG. 11 provides a block diagram of portions of a facility with a three-way diverting valve and a parallel input device in accordance with a seventh embodiment.

[0021] FIG. 12 provides a system curve showing the relationship between flow and differential pressure for the embodiment of FIG. 11.

[0022] FIG. 13 provides a block diagram of portions of a facility with a three-way diverting valve and a serial input device in accordance with a seventh embodiment.

[0023] FIG. 14 provides a system curve showing the relationship between flow and differential pressure for the embodiment of FIG. 13.

[0024] FIG. 15 provides a block diagram of a portion of a facility that uses a pump and a three-way diverting valve in accordance with an eighth embodiment.

[0025] FIG. 16 provides a system curve showing the relationship between flow and differential pressure for the embodiment of FIG. 15.

[0026] FIG. 17 provides a block diagram of a portion of a facility that uses a pump and a three-way diverting valve in accordance with a ninth embodiment.

[0027] FIG. 18 provides a system curve showing the relationship between flow and differential pressure for the embodiment of FIG. 17.

[0028] FIG. 19 provides a graph showing the relationship between applied heating percentage for a space and a signal sent to a device to control the percentage of heating applied to the space.

[0029] FIG. 20 provides a graph showing the relationship between applied heating percentage for a space and a percent of the time that a signal sent to an on/off device causes the device to be on.

[0030] FIG. 21 provides a block diagram that generalizes the facilities of FIGS. 1, 2, 3, 5, 7, 9, 11, 13, 15, and 17.

[0031] FIG. 22 provides a flow diagram of a method performed by a boiler set point algorithm to adjust a boiler fluid set point in accordance with one embodiment.

[0032] FIG. 23 provides a flow diagram of a method of identifying input devices that should not be used to adjust boiler fluid set point and for identifying input devices that should be added back to the list of input devices that are used to adjust the boiler set point.

[0033] FIG. 24 provides a flow diagram of a method of generating a change log for a boiler fluid set point.

[0034] FIG. 25 provides a flow diagram for generating a controller-determined reset curve.

[0035] FIG. 26 provides a graph showing a base reset curve and a controller-determined reset curve.

[0036] FIG. 27 is a block diagram of a computing device that can implement the controller functions.

DETAILED DESCRIPTION

[0037] Embodiments provide a system and method establish the lowest boiler fluid set point that provides a desired temperature in all of the spaces heated by a hydronic heating system. Control is based upon gathering a plurality of inputs that are indicative of if the current boiler fluid set point is too low to adequately maintain the desired space temperatures in a facility or too high and therefore inefficient. Each of the various inputs is compared to a set point for each input device and a deviation from set point is calculated.

[0038] If the deviation for any input device is greater than a programmable value for a programmable period of time, the boiler fluid set point is increased. If none of the input device deviations are outside the programmable value for a programmable period of time, the boiler fluid set point is decreased. The programmable period of time can be either manually set or the control can calculate it based upon the time period measured for a change in boiler fluid supply temperature to affect the boiler fluid return temperature. The optimization establishes the lowest possible boiler fluid set point temperature and highest possible boiler system efficiency that provides adequate comfort heat.

[0039] The system records or stores the temperature of each space (if data is provided), the deviation from set point for each space's set point, the deviation from set point of other input devices such as a flow meter, the boiler inlet and outlet fluid temperatures, fuel flow amount, boiler fluid flow rate, individual loop flow rates, pump speeds, differential pres-

ures, and the fuel BTU's consumed in the boiler(s). The control uses the stored values to generate a report that indicates the spaces and input devices that most often prevent the boiler fluid set point from being lowered. The report is used to change components or make adjustments to control settings so that the space(s) operate in such a way to provide adequate heat to the space(s) at a lower fluid temperature. Examples of this can be pump or control valve sizes, fan speed or plugged filters.

[0040] The control uses historical data from the use of the optimization of boiler fluid set points to establish a baseline of optimized set points based upon time of day, day of week and ambient temperature, for example. The control can utilize that reset curve of boiler temperature set points after power is restored following a power failure or as a baseline of boiler temperature set points that is further optimized based on real time operation.

[0041] FIG. 1 provides a simplified block diagram of a facility 100 in which embodiments may be practiced. Facility 100 includes one or more boilers 102 that receive a fluid at an inlet 106, heat the received fluid, and provide a heated fluid at an outlet 104. By way of example, and not limitation, boiler 102 can include one or more of a fire-tube boiler, water-tube boiler, cast-iron boiler, cast-aluminum boiler, and a hybrid or combination boiler having fire-tube and water-tube sections, for example. In many embodiments, boiler 102 is a condensing-type boiler that condenses flue gases to extract heat from the flue gases. Boiler inlet 106 and boiler outlet 104 are connected to a primary loop 108 that carries the fluid from boiler outlet 104 to one or more secondary loops, such as secondary loop 112, and back to inlet 106. In accordance with some embodiments, a pump 110 moves the fluid through primary loop 108. As used herein, "primary loop" refers to a fluid line or path that is connected to one or more units that are configured to heat fluid (e.g., fuel burning units (such as boilers) and/or heat recovery units (such as condensers)). As used herein, "secondary loop" refers to a fluid line or path that is connected to end-use points for the fluid, such as one or more terminal units. A secondary loop can comprise a closed fluid circuit or an open fluid circuit. For example, a secondary loop can be connected to terminal unit(s) that are configured to use fluid in the secondary loop that is not returned to the secondary loop.

[0042] Secondary loop 112 is selectively connected to primary loop 108 by a loop coupling 114 such that heat from primary loop 108 is coupled to secondary loop 112. Loop coupling 114 can include thermal coupling and/or fluidic coupling. In thermal coupling, a heat exchange or thermal transfer is used to transfer heat from primary loop 108 to secondary loop 112 while keeping the fluid of primary loop 108 separate from the fluid of secondary loop 112. In fluidic coupling, valves are used to selectively admit heated fluid from primary loop 108 into secondary loop 112.

[0043] In secondary loop 112, a pump 116 moves fluid through the loop so that it reaches terminal units 118. A terminal unit can include any device configured to perform a function using the fluid. For example, a terminal unit can include a device configured to heat a space or a process using the heat from the fluid, such as a radiator, unit ventilator, air handling unit, and the like. In another example, a terminal unit can include a device configured to perform a cleaning or washing function.

[0044] A controller 120 is provided that determines a boiler temperature set point for boiler 102. The boiler temperature

set point is the temperature for the fluid at outlet **104** of boiler **102**. As discussed further below, the boiler temperature set point can be determined in a number of ways. In accordance with some embodiments, the boiler temperature set point is set based in part on values generated by one or more parallel input devices **122** in secondary loop **112** and/or one or more serial input devices **124** in secondary loop **112**. A parallel input device **122** is positioned in parallel with terminal units **118** of secondary loop **112**, while a serial input device **124** is positioned in series with terminal units **118**.

[0045] In other embodiments, controller **120** determines boiler set points based on one or more of a temperature of the fluid at boiler outlet **104** as determined by a temperature sensor **126**, a temperature of the fluid at boiler inlet **106** as determined by temperature sensor **128**, an amount of fuel used by boiler **102** as determined by fuel meter **130**, and a flow of the fluid through primary loop **108** as determined by flow meter **132**.

[0046] In accordance with one embodiment, controller **120** also determines BTU usage and system efficiency. In such embodiments, the percentage and type of glycols used (if any) are manually inputted by a user. BTU's absorbed by the boiler(s) is accomplished using the fluid properties of the boiler fluid, the flow rate of the boiler fluid provided by flow meter **132**, and the temperatures provided by temperature sensors **126** and **128**. Instantaneous BTU usage of fuel supplied to the boiler burner(s) is supplied to controller **120** by fuel meter **130**. Controller **120** calculates the net thermal efficiency of the boilers by dividing the BTU's absorbed by the boiler(s) by the BTU's of fuel consumed by the boiler(s). The efficiency is calculated regardless of the method used to designate the boiler fluid set point.

[0047] FIG. 2 provides an alternative facility **200** in which facility **100** of FIG. 1 has been expanded to include two additional secondary loops **222** and **250**, that are coupled to primary loop **108** by respective loop couplings **214** and **244**. Loop couplings **214** and **244** may be either thermal couplings or fluidic couplings as discussed above for loop coupling **114**. Secondary loop **222** includes a pump **216** that pumps fluid through terminal units **218**, and secondary loop **250** includes a pump **246** that pumps fluid through terminal units **248**. Terminal units **218** and **248** can be any device configured to perform a function using the fluid. For example, a terminal unit can include a device configured to heat a space or a process using the heat from the fluid, such as a radiator, unit ventilator, air handling unit, and the like. In another example, a terminal unit can include a device configured to perform a cleaning or washing function.

[0048] Secondary loops **222** and **250** also include parallel input devices **232** and **252**, which are parallel to their respective terminal units **218** and **248**. Secondary loops **222** and **250** also include serial input devices **224** and **254**, which are connected in series with their respective terminal units **218** and **248**. Controller **120** receives values from parallel input devices **232** and **252** and/or serial input devices **224** and **254** either wirelessly or through a wired connection. One example of an input device is a thermostat in a heated space whose actual temperature is transmitted to controller **120**.

[0049] FIG. 3 provides a block diagram of a portion of a facility **300** with a parallel input device in accordance with a third embodiment. In FIG. 3, a primary loop **301** is coupled to four secondary loops **302**, **304**, **306**, and **308** by three respective coupling valves **312**, **314**, **416**, and **318**, which act as loop couplings. A parallel input device **310** extends in parallel

across each of secondary loops **302**, **304**, **306**, and **308**. In the embodiment of FIG. 3, parallel input device **310** takes the form of a differential pressure sensor that provides a value indicative of the pressure difference between the output of variable speed pump **330** of primary loop **301** and return line **332**, which returns to the boiler (not shown). As shown in FIG. 3, a reduction in the differential pressure value is associated with an increase in the flow through terminal units **320**, **322**, **324**, and **326** serviced by variable speed pump **330**. This increase in flow is triggered by one or more of valves **312**, **314**, **316**, and **318** being opened further or cycled more often in order to pump more fluid through the terminal units to raise the temperature of the spaces serviced by the terminal units. If the differential pressure remains below a trigger threshold, it is an indication that the boiler fluid set point may be too low to heat the space.

[0050] FIG. 4 provides pump curves and system graphs showing the relationships between flow and differential pressure for the embodiment of FIG. 3. In FIG. 4, flow is shown on horizontal axis **402** and differential pressure from the outlet of pump **330** to return line **332** is shown on vertical axis **404**. Graphs **406**, **408**, and **410** provide pump curves for three different speeds of variable speed pump **330**. As shown by graphs **406**, **408**, and **410**, increased differential pressure is associated with a reduction in flow rate for any given speed of pump **330**. Graphs **412**, **414**, and **416** are system curves that show the total flow as a function of differential pressure for various states of the valves. Graph **412** shows the total flow as a function of the differential pressure with all valves closed all the time. Graph **414** shows the total flow as a function of the differential pressure with all valves open all the time. Comparing graph **412** to graph **414** it can be seen that with more valves open, there will be greater flow for the same amount of differential pressure. Graph **416** shows the total flow as a function of the differential pressure with the valves open a desired amount.

[0051] When the valves are opened a desired amount, the flow follows graph **416** and the variable speed pump operates along curve **408**. The intersection of these two graphs corresponds to a differential pressure set point **420** for input device **310**. When the valves are all open, indicating that the spaces serviced by terminal units **320**, **322**, **324**, and **326** are not warming enough, the total system flow follows graph **414** and the pump speeds up to follow pump curve **406**. The intersection of graphs **414** and **406** corresponds with a deviated pressure value **422** for input device **310**. The difference between deviated pressure value **422** and set point pressure value **420** is a pressure deviation **430**.

[0052] FIG. 5 provides a block diagram of a portion of a facility **500** in accordance with a fourth embodiment. Facility **500** is similar to facility **300** except that differential pressure transmitter **310** has been removed and serial input device **502** has been added at the outlet of variable speed pump **330**. In FIG. 5, serial input device **502** is a flow meter that provides a measure of the fluid flow through primary loop **301** and secondary loops **302**, **304**, **306**, and **308**. FIG. 6 provides pump curves and system graphs showing the relationships between flow and differential pressure for the embodiment of FIG. 5. In particular, FIG. 6 shows pump curve graphs **606**, **608**, and **610** and system curves **612**, **614**, and **616**. The intersection of graphs **616** and **608** occurs when the valves are open a desired amount and the intersection of graphs **614** and **606** occurs when the valves are open all the time indicating that spaces serviced by terminal units **320**, **322**, **324**, and **326**

are not receiving enough heat. The intersection of graphs 616 and 608 corresponds to a flow value 600 from input device 502 and the intersection of graphs 614 and 606 corresponds to a flow value 602 from input device 502. The difference between flow value 600 and flow value 602 is a deviation 604.

[0053] FIG. 7 provides a block diagram of a portion of a facility 700 in accordance with a fifth embodiment. Facility 700 is formed by replacing variable speed pump 330 of FIG. 3 with a constant speed pump 702. All the remaining elements of FIG. 7 are the same as FIG. 3. FIG. 8 provides pump curves and system graphs showing the relationships between flow and differential pressure for the embodiment of FIG. 7. Graph 800 is the relationship between flow and differential pressure when valves 312, 314, 316, and 318 are opened a desired amount and graph 802 is the relationship between flow and differential pressure when valves 312, 314, 316, and 318 are opened more than the desired amount. In FIG. 8, only a single pump curve 804 is provided since constant speed pump 702 can only operate at a single speed. The intersection of graph 800 and graph 804 occurs when the valves are opened a desired amount and corresponds with a set point differential pressure 806. The intersection of graph 802 and graph 804 occurs when the valves are open more than desired and corresponds to a deviated differential pressure 808. The difference between set point 806 and deviated pressure 808 is pressure deviation 810.

[0054] FIG. 9 shows a block diagram of a portion of a facility 900 with a serial input device and a constant speed pump in accordance with a sixth embodiment. Facility 900 that is formed by replacing variable speed pump 330 of FIG. 5 with a constant speed pump 902. All the remaining elements of FIG. 9 are the same as FIG. 5. FIG. 10 provides pump curves and system graphs showing the relationships between flow and differential pressure for the embodiment of FIG. 9. System curve 1000 is the relationship between flow and differential pressure when valves 312, 314, 316, and 318 are opened a desired amount and system curve 1002 is the relationship between flow and differential pressure when valves 312, 314, 316, and 318 are opened more than the desired amount. In FIG. 10, only a single pump curve 1004 is provided since constant speed pump 902 can only operate at a single speed. The intersection of graph 1000 and graph 1004 occurs when the valves are opened a desired amount and corresponds with a set point flow 1006. The intersection of graph 1002 and graph 1004 occurs when the valves are open more than desired and corresponds to a deviated flow 1008. The difference between set point 1006 and deviated flow 1008 is flow deviation 1010.

[0055] FIG. 11 provides a block diagram of portions of a facility 110 with a three-way diverting valve 1102 and a parallel input device 1108 in accordance with a seventh embodiment. Three-way diverting valve 1102 controls how the fluid from the boiler is divided between a return line 1106 and a terminal unit 1104. Parallel input device 1108 is placed in parallel across terminal unit 1104 and provides differential pressure values to controller 120. FIG. 12 provides a system curve 1200 showing the relationship between flow and differential pressure for the embodiment of FIG. 11. In particular, system curve 1200 shows the relationship between flow and differential pressure across terminal unit 1104. As shown in FIG. 12, when valve 1102 directs a desired amount of fluid flow through terminal unit 1104, the differential pressure has a set point value 1202. When terminal unit 1104 is unable to heat the space adequately, valve 1102 directs more than the

desired amount of fluid flow through terminal units 1104 resulting in a deviated differential pressure 1204. The difference between set point value 1202 and deviated differential pressure 1204 is a pressure deviation 1206.

[0056] FIG. 13 provides a block diagram of portions of a facility 1300 with a three-way diverting valve 1302 and a serial input device 1308 in accordance with a seventh embodiment. Three-way diverting valve 1302 controls how the fluid from the boiler is divided between a return line 1306 and a terminal unit 1304. A serial input device 1308 is placed in series between three-way diverting valve 1302 and terminal unit 1304 and provides flow values to controller 120. FIG. 14 provides a system curve 1400 showing the relationship between flow and differential pressure for the embodiment of FIG. 13. In particular, system curve 1400 shows the relationship between flow and differential pressure across terminal unit 1304. As shown in FIG. 14, when valve 1302 directs a desired amount of fluid flow through terminal unit 1304, the flow has a set point value 1402. When terminal unit 1304 is unable to heat the space adequately, valve 1302 directs more than the desired amount of fluid flow through terminal unit 1304 resulting in a deviated flow 1404. The difference between set point value 1402 and deviated flow 1404 is a flow deviation 1406.

[0057] FIG. 15 provides a block diagram of a portion of a facility 1500 that uses a pump 1502 and a three-way diverting valve 1504 to control the fluid flow through a terminal unit 1506 in accordance with an eighth embodiment. A parallel input device in the form of differential pressure transmitter 1508 extends across terminal unit 1506. Differential pressure transmitter 1508 produces a differential pressure value that is provided to controller 120. FIG. 16 provides a system curve 1600 showing the relationship between flow and differential pressure for terminal unit 1506 of FIG. 15. When valve 1504 and pump 1502 direct a desired amount of the boiler fluid through terminal unit 1506, the differential pressure is at a set point 1602. When valve 1504 and pump 1502 direct more than the desired amount of the boiler fluid through terminal unit 1506, the differential pressure is at a deviated pressure value 1604. The difference between set point value 1602 and deviated value 1604 is deviation 1606.

[0058] FIG. 17 provides a block diagram of a portion of a facility 1700 that uses a pump 1702 and a three-way diverting valve 1704 to control the fluid flow through a terminal unit 1706 in accordance with a ninth embodiment. A serial input device in the form of flow meter 1708 is positioned in series between three-way diverting valve 1704 and terminal unit 1706. Flow meter 1708 produces a flow value that is provided to controller 120. FIG. 18 provides a system curve 1800 showing the relationship between flow and differential pressure for terminal unit 1706 of FIG. 17. When valve 1704 and pump 1702 direct a desired amount of the boiler fluid through terminal unit 1706, the flow through terminal unit 1706 is at a set point 1802. When valve 1704 and pump 1702 direct more than the desired amount of the boiler fluid through terminal unit 1706, the differential pressure is at a deviated pressure value 1804. The difference between set point value 1802 and deviated value 1804 is deviation 1806.

[0059] FIG. 19 shows a graph 1900 showing the relationship between applied heating percentage for a space and a signal sent to a device to control the percentage of heating applied to the space. The signal may be sent by a Building Maintenance System (BMS) to control a device such as an analog control valve, pump speed, fan speed or dampers, for

example. Although the signal is generated by the Building Management System, the input device is considered to be the device that is being controlled by the signal. For instance, if a fan is being controlled by the control signal, the fan is the input device for the controller and the control signal to the fan is the input value for controller 120. As shown in FIG. 19, when the signal produces a desired percentage of possible applied heating, the signal is at a set point 1902. When the signal produces more than the desired percentage of applied heating it is at a deviated value 1904. The difference between set point 1902 and deviated value 1904 is a deviation 1906.

[0060] FIG. 20 shows a graph 2000 showing the relationship between applied heating percentage for a space and a percent of the time that a signal sent to an on/off device causes the device to be on. The signal may be sent by a Building Maintenance System (BMS) to control an on/off device such as an on/off valve, an on/off pump, an on/off fan or an on/off damper, for example. Although the signal is generated by the Building Management System, the input device is considered to be the device that is being controlled by the signal. For instance, if a fan is being controlled by the control signal, the fan is the input device for the controller and the control signal to the fan is the input value for controller 120. As shown in FIG. 20, when the signal produces a desired applied heating percentage, the signal is cycling the device on at a set point percentage 2002. When the signal produces more than desired applied heating percentage, the signal is cycling the device on at a deviated percentage 2004. The difference between set point 2002 and deviated value 2004 is a deviation 2006.

[0061] FIG. 21 provides a block diagram that generalizes the facilities of FIGS. 1, 2, 3, 5, 7, 9, 11, 13, 15, and 17 shown above. In FIG. 21, controller 120 is shown with input device(s) 2100, a Building Management Control System (BMS) 2102 and a boiler 102. Input device(s) 2100 include any one of the parallel or serial input devices discussed above as well as thermostats and other temperature sensors placed in a space or device serviced by a terminal unit.

[0062] Controller 120 includes a memory 2104, which stores a number of records including input device records 2106, boiler set point change records 2108, and efficiency records 2110. Input device record 2106 stores values associated with an input device that are used to determine whether input values from the input device are currently being used to adjust a boiler set point 2126, when an input value from the input device should be used to adjust boiler set point 2126, and whether the input device should be dropped from being used to adjust boiler set point 2126. Boiler set point change records 2108 store information related to an adjustment in boiler set point 2126 and efficiency records 2110 store information used to determine the efficiency of the boiler.

[0063] FIG. 22 provides a flow diagram of a method performed by a boiler set point algorithm 2124 in controller 120 to adjust boiler fluid set point 2126 in accordance with one embodiment. At step 2200, a separate input device record 2106 is created for each input device 2100, with each record having a unique input device ID 2111. In accordance with one embodiment, each input device is associated with a space or area and a name of the space is stored as space name 2113. Within each created input device record 2106, an input device set point is stored as set point 2112. Set point 2112 represents a desired value for the input signal from the input device. For

example, for a temperature sensor input device, set point 2112 would be the desired temperature of the space where the temperature sensor is located.

[0064] At step 2202, input values are received by controller 120 from one or more of the input devices 2100. At step 2204, the difference between the value received at step 2202 and set point 2112 is calculated to form a deviation value for each input device. The deviation value is calculated such that it is positive when the boiler fluid set point is too low. For example, when the input device is a temperature sensor, the deviation would be calculated such that it is a positive value when the temperature in the space is below set point 2112.

[0065] At step 2206, the deviation value of each input device is compared to a respective deviation trigger value 2114 in the input device's record 2106. If any of the deviation values calculated in step 2204 exceeds the respective deviation trigger value 2114, a Raise Set Point timer 2116 is started in controller 120 at step 2208. Raise Set Point timer 2208 is set to expire at a desired amount of time that is selected to allow the deviations to drop below the deviation trigger values without increasing the boiler fluid set point. At step 2210, a Lower Set Point timer 2118 is stopped and reset if it is currently running. The purpose of Lower Set Point timer 2118 is discussed further below.

[0066] At step 2214, boiler set point algorithm 2124 determines if Raise Set Point timer 2116 has expired. If Raise Set Point timer 2116 has not expired, the process returns to step 2202 and new input device values are received. If the Raise Set Point timer 2116 has expired at step 2214, the boiler fluid set point 2126 is increased by a programmable amount as long as the current boiler fluid set point is less than a boiler fluid set point maximum 2120. In some embodiments, boiler fluid set point maximum 2120 is taken from a base reset curve 2132 which provides boiler fluid set points as a function of an outside air temperature. Using the current outside air temperature, boiler set point algorithm 2124 determines the associated boiler fluid set point from the base curve. This associated boiler fluid set point is then used as boiler set point maximum 2120.

[0067] After the boiler fluid set point has been increased at step 2216, Raise Set Point timer 2116 is reset at step 2218 and the process returns to step 2202, where new input device values are received.

[0068] If at step 2206, if none of the deviation values are greater than the deviation trigger values 2114, Lower Set Point timer 2118 is started or continued at step 2220. Lower Set Point timer 2118 is set to a period of time such that if no input devices have a deviation that exceeds their respective deviation trigger value 2214 during the time period, the boiler fluid set point may be higher than needed. At step 2222, Raise Set Point timer 2116 is stopped and reset if it is currently running because the fact that none of the input devices are exceeding their respective deviation trigger value 2214 means that the boiler fluid set point is not too low.

[0069] At step 2224, boiler set point algorithm 2124 determines if Lower Set Point timer 2116 has expired. If Lower Set Point timer 2116 has not expired at step 2224, the process returns to step 2202 and receives new input values. If Lower Set Point timer 2116 has expired at step 2224, boiler fluid set point 2126 is lowered by a programmable amount at step 2226 as long as the current boiler fluid set point is greater than a minimum boiler fluid set point. After boiler fluid set point

2126 has been lowered at step **2226**, Lower Set Point timer **2118** is reset at step **2228** and the process returns to step **2202** to receive new input values.

[**0070**] Boiler set point algorithm **2124** may alternatively use a constant boiler set point **2128** as boiler fluid set point **2126** or may use a controller-determined reset curve **2130** or base reset curve **2132** to set the boiler fluid set point. Constant boiler set point **2128** is entered by a user through a user interface generated by controller **120**. Controller-determined reset curves **2130** and base reset curve **2132** provide boiler fluid set points as a function of the outdoor temperature (also referred to as the ambient temperature). Using the current outdoor temperature, boiler set point algorithm **2124** determines the associated boiler fluid set point **2126** from controller-determined reset curve **2130** or base reset curve **2132** and sets the associated boiler fluid set point as boiler fluid set point **2126**. A technique for establishing controller-determined reset curve **2130** is discussed further below.

[**0071**] In accordance with some embodiments, whenever the boiler set point is adjusted a set point change record **2108** is generated. Boiler set point change record **2108** includes parameters of the facility when the boiler set point was changed. These parameters include boiler inlet fluid temperature **2134**, boiler outlet fluid temperature **2136**, previous boiler set point **2138**, temperature of all spaces **2140**, deviation from set points for all spaces **2142**, outdoor temperature **2144**, adjusted boiler set point **2146**, day of week **2148**, date **2150**, time **2152** and the input device ID **2154** of the input device or devices that cause the boiler set point to be changed. The parameters shown in set point change record **2108** are exemplary and more or fewer of the parameters may be stored.

[**0072**] In accordance with some embodiments, the input values from some input devices are not used to adjust the boiler set point. Examples of input devices that are not used include input devices that serve spaces that are not currently being heated or spaces with failed equipment such as failed controller valves, faulty thermostats, failed pumps or a failed fan, for example. Other examples include spaces that are exposed to outside air for prolonged periods of time such as loading docks where the terminal units cannot add enough heat to overcome the cold air entering the space.

[**0073**] FIG. **23** provides a flow diagram of a method of identifying and utilizing how often an input device causes the boiler set point to increase and how often the input device prevents the boiler set point from being reduced. As part of the method of FIG. **23**, input devices are identified that should not be used to adjust the boiler set point. The process of FIG. **23** is performed on a per input device basis.

[**0074**] At step **2300**, the process of FIG. **23** determines if the deviation of the input signal from the input device exceeds deviation trigger value **2114**. If it does not exceed the trigger value, the process proceeds to step **2302** where it stops any duration timers that may be running. Initially, there are no duration timers running. After step **2302**, the process returns to step **2300** and the loop between steps **2300** and **2302** is repeated until the deviation of the input signal exceeds input trigger value **2114** at step **2300**.

[**0075**] When the deviation value exceeds deviation trigger value **2114**, a duration timer **2156** (FIG. **21**) is started at step **2301** if it is not currently running. Duration timer **2156** keeps track of the total amount of time that the deviation value of the input device exceeds deviation trigger value **2114**.

[**0076**] At step **2303**, controller **120** determines if Lower Set Point timer **2118** is currently running. If Lower Set Point timer **2118** is currently running, it means that no other input devices have a deviation value that exceeds their deviation trigger value. As a result, because the current input device has a deviation value that exceeds its deviation trigger value **2114**, the current input device is responsible for preventing the boiler fluid set point from being reduced. As such, one is added to a Prevent Boiler Set Point Reduction Count **2167** (input device record **2106** of FIG. **21**) at step **2305**. Prevent Boiler Set Point Reduction Count **2167** keeps track of the number of times an input device prevented a reduction in the boiler fluid set point since the last time a boiler set point change log **2172** was generated.

[**0077**] After step **2305**, or if Lower Set Point timer **2118** has not expired at step **2303**, the process continues at step **2304** where the current deviation value of the input device is stored as initial deviation value **2158** in input device record **2106**.

[**0078**] At step **2306**, controller **120** determines a new deviation value for the input device and determines if this new deviation value is less than initial deviation value **2158**. If the new deviation value is not less than initial deviation value **2158**, the process continues at step **2308** where it determines if the boiler set point has been increased. If the boiler set point has not been increased, the process returns to step **2306** and a new deviation value is compared to initial deviation value **2158**. The loop of steps **2306** and **2308** continues until the new deviation value is less than initial deviation value **2158** or the boiler set point is increased at step **2308**.

[**0079**] When the boiler set point is increased to step **2308**, a drop count **2160** in input device record **2106** is increased by one at step **2310**. Drop count **2160** keeps track of the number of times that the input device was at least partially responsible for an increase in the boiler set point. At step **2312**, the process determines if the current drop count is greater than a drop count threshold **2162** of input device record **2106**. Drop count threshold **2162** represents the value of drop count **2160** that will cause the input device to be dropped from consideration by boiler set point algorithm **2124**. If the drop count is not greater than the drop count threshold, the process returns to step **2308** and the loop of steps **2308** and **2306** are repeated.

[**0080**] If drop count **2160** exceeds drop count threshold **2162** at step **2312**, the device is removed from boiler set point algorithm **2124** at step **2314** by setting the device as DROPPED in active/inactive field **2164** of input device record **2106**. Active/inactive field **2164** can have values of DROPPED, ACTIVE, and manually set INACTIVE. The input values of an ACTIVE input device will be used in boiler set point algorithm **2124** while the input values of a DROPPED or manually set INACTIVE input device will not be used in boiler set algorithm **2124**. An input device may be manually set as INACTIVE using a user interface.

[**0081**] After a device has been removed or dropped from consideration by boiler set point algorithm **2124** at step **2314**, the method enters a loop at step **2316** where it waits to reinstate the dropped input device. In step **2316**, new deviation values of the device are compared to initial deviation value **2158**. As long as the new deviation values are not less than initial deviation value **2158**, controller **120** will remain in loop **2316**. However, once a new deviation value is less than initial deviation value **2158**, the process will continue at step **2318** where active/inactive field **2164** will be changed to ACTIVE to reinstate the input device as part of boiler set point algorithm **2124**. After a device is reinstated or if a new

deviation value is less than initial deviation value **2518** at step **2306**, the current value of drop count **2160** is added to a boiler set point increase count **2168** and drop count **2160** is reset at step **2320**. Boiler set point change count **2168** keeps track of the number of times the input device caused a boiler set point increase since a last time a boiler set point change log **2172** was generated. After step **2320**, the process returns to step **2300** to determine if a new input device deviation value exceeds device trigger value **2114**. If the new deviation value exceeds the device trigger value, the process continues at step **2301** and the steps that follow thereafter. If the new deviation value does not exceed the trigger value at step **2300**, step **2302** is performed where the current duration time of duration timer **2156** is added to deviation time **2166** and duration timer **2156** is stopped and reset. Deviation time **2166** keeps track of the amount of time that the deviation of the input device has exceeded the deviation trigger value since the last time that boiler set point change log **2172** was generated.

[0082] In accordance with some embodiments, a dropped device log **2170** is generated periodically or in response to a request made by a user through a user interface. A typical time span for periodically generating dropped device log **2170** would be every 24 hours. Dropped devices log **2170** lists all the devices with an active/inactive field **2164** set to DROPPED and may include input device ID **2111** and/or space name **2113** of each DROPPED device. Dropped devices log **2170** may be communicated to the user through any variety of means including a touchscreen of a human-machine interface, an email or some other communication means. The log can be written to a comma separated value (CSV) file on a removable media and/or stored in controller **120**'s memory **2104**. Dropped devices log **2170** may be generated by a log generator **2174** which produces a log user interface **2176** that can be used to request the generation of dropped devices log **2170**.

[0083] Log generator **2174** can also generate boiler set point change log **2172** using the process shown in the flow diagram of FIG. **24**. At step **2400**, log generator **2174** starts a data log timer **2178**. After data log timer **2178** is started, controller **120** adjusts the boiler set point based on deviation values for the input devices and stores the boiler set point information in set point change records **2108** and input device records **2106**. This is shown as step **2402** in FIG. **24**. At step **2404**, data log timer **2178** expires or the user calls for the creation of boiler set point change log **2172** using log user interface **2176**. At step **2406**, log generator **2174** identifies all the input devices that either caused the boiler set point to increase or prevented the boiler set point from being decreased by examining boiler set point increase count **2168** and prevent boiler set point reduction count **2167** of each input device record **2106**.

[0084] At step **2408**, log generator **2174** ranks the input devices on one or more measures such as deviation time **2166**, boiler set point change count **2168** and prevent boiler set point reduction count **2167**. In some embodiments, multiple ranked lists are provided, each ranked on a separate measure. In other embodiments, boiler set point change log **2172** is presented as an interactive user interface in which a user may select the parameter that is to be used to rank the input devices. In response to this selection, the user interface adjusts the list to show the input devices ranked according to the newly selected parameter. The input devices are identified in the ranked list by either the input device ID **2111** or space name **2113**.

[0085] Boiler set point change log **2172** may be communicated to the user through any variety of means including a touchscreen of a human-machine interface, an email or some other communication means. The log can be written to a comma separated value (CSV) file on a removable media and/or stored in controller **120**'s memory **2104**.

[0086] At step **2410**, deviation time **2168**, boiler set point change counter **2168**, and prevent boiler set point reduction count **2167** of each input device are reset to 0. In addition, data log timer **2178** is reset to 0. The process then returns to step **2400** to restart data log timer **2178**.

[0087] In some embodiments, log generator **2174** also produces a boiler efficiency log **2180**. A separate entry is added to boiler efficiency log **2180** periodically, such as every hour. To produce a log entry for boiler efficiency log **2180**, controller **120** determines BTU usage and system efficiency. In such embodiments, the percentage and type of glycols used (if any) are manually inputted by a user and stored in an efficiency record **2110** in memory **2104** as glycol parameters **2182**. Similarly, fluid properties of the boiler fluid are received from the user and are stored as boiler fluid properties **2183**. Every hour, the flow rate of the boiler fluid as provided by flow meter **132** is stored as boiler fluid flow **2188** in an efficiency record **2110**. The temperatures provided by temperature sensors **126** and **128** are stored as boiler outlet fluid temp **2184** and boiler inlet fluid temp **2182**, respectively, in efficiency record **2110**. The amount of fuel supplied to the boiler burner(s) as indicated by fuel meter **130**, is stored as fuel flow **2190**. When boiler efficiency log **2180** is written, controller **120** determines a BTU usage of fuel by the boiler burner(s) using fuel flow **2190** and glycol parameters **2182**. Controller **120** also determines BTU's absorbed by the boiler(s) using fluid properties **2183** of the boiler fluid, flow rate **2188** of the boiler fluid, boiler outlet fluid temp **2186** and boiler inlet fluid temp **2184**. Controller **120** calculates the net thermal efficiency of the boilers by dividing the BTU's absorbed by the boiler(s) by the BTU's of fuel consumed by the boiler(s). Controller **120** also records the method used to designate the boiler fluid set point when the efficiency was calculated. The efficiency is calculated regardless of the method used to designate the boiler fluid set point.

[0088] In some embodiments, controller **120** also determines the controller-determined reset curve **2130**. A reset curve provides initial boiler set points when controller **120** has been restarted and before controller **120** receives input values from input devices **2100**. As noted above, reset curves **2130** and **2132** provide values for boiler set point **2126** for different outdoor (ambient) temperatures.

[0089] FIG. **25** provides a flow diagram for generating a controller-determined reset curve **2130**. At step **2500**, controller **120** creates a set point change record **2108** for each adjustment of the boiler temperature set point. Each boiler set point change record **2108** includes information such as the boiler input fluid temperature **2134**, the boiler outlet fluid temperature **2136**, the previous boiler set point **2138**, the temperature of all spaces **2140**, the deviation from the set point of all spaces **2142**, the outdoor temperature **2144**, the adjusted boiler set point **2146**, the day of the week **2148**, the date **2150**, the time **2152**, the input device ID **2154** of the device that caused the boiler temperature set point change, and the space name **2155** of the space or area serviced by the input device.

[0090] At step **2502**, controller **120** receives or retrieves reset curve bin definitions **2180**. Reset curve bin definitions

2180 define sets of parameter values used to group boiler fluid set point changes. The bin definitions may be based on more than one parameter. For example, multiple bins may be defined for each day of the week with each bin for a day of a week being defined for a separate range of temperatures. Thus, there would be multiple bins for Tuesdays, with one bin for an outdoor temperature range of 30° F. to 50° F. and another bin for an outdoor temperature range of 51° F. to 65° F., for example. Similarly, there would be multiple bins defined for Wednesdays, with one bin for an outdoor temperature range of 30° F. to 50° F. and another bin for an outdoor temperature range of 51° F. to 65° F., for example. There would be additional bins for each day for other temperature ranges. Additional parameters may be used to define additional bins such as defining bins based time of day in addition to the day of the week and the temperature range.

[0091] At step **2504**, each adjusted boiler temperature set point is assigned to one of the bins defined by reset curve bin definitions **2180**. To assign an adjusted boiler temperature set point, the values in set point change record **2108** are used to identify the appropriate bin. For example, if the bins are defined based on the day of the week and the outdoor temperature, day of the week value **2148** and outdoor temperature value **2144** of the set point change record would be used to identify which bin set point change record **2108** should be associated with.

[0092] After all of the boiler temperature set point adjustments have been assigned to a bin, a bin is selected at step **2506** and the bin is examined at step **2508** to determine if there is at least one adjusted boiler temperature set point in the bin. If there are no adjusted boiler temperature set points in the bin, the current reset point for the bin is kept at step **2510**. The current reset point can be a base reset point that is set when the bin is defined at step **2502** or could be the latest reset point found in controller-determined reset curve **2130**. If the current reset point is kept at step **2510**, the process returns to step **2512** where it determines if there are more bins. If there are more bins, the process returns to step **2506** to select a new bin.

[0093] If there is at least one adjusted boiler temperature set point in the bin at step **2508**, the process continues at step **2514** where it determines a candidate reset point for the bin from the adjusted boiler set points in the bin. The candidate reset point for the bin can be the maximum adjusted boiler temperature set point, the average adjusted boiler temperature set point or the median adjusted boiler temperature set point, for example. At step **2516**, the candidate reset point for the bin is compared to the current reset point for the bin. If the candidate reset point for the bin is greater than the current reset point for the bin, the current reset point for the bin is kept at step **2510**. If the candidate reset point for the bin is not greater than the current reset point for the bin, the candidate reset point is made the new reset point for the bin at step **2518**. After step **2518**, the process returns to step **2512** to see if there are more bins. When there are no more bins at step **2512**, controller **120** defines one or more controller-determined reset curves **2130** from the bin reset points at step **2520**. In accordance with one embodiment, if multiple parameters define the bins, multiple curves can be generated. In general, each curve provides boiler temperature set points as a function of the ambient temperature or the time of day, for example. The curves are formed by associating the boiler temperature reset point of each bin with a central point of the bin such as a median temperature of the bin or a median time for the bin. Lines connecting the combination of the boiler

temperature reset point and the median value of the bin are then created to thereby produce the controller-determined reset curves **2130**.

[0094] FIG. 26 provides a graph showing a base reset curve **2600** and a controller-determined reset curve **2602**, which both show the relationship between outdoor air temperature **2604** and a boiler temperature set point **2606**. As shown in FIG. 26, the controller-determined reset curve **2130** has lower boiler temperature set points than base reset curve **2132**. Since controller-determined reset curve **2130** is based on the optimization steps of FIG. 22, it produce lower boiler temperature reset points than base reset curve **2132**. As a result, the facility will initially start with lower boiler temperature set points and thus be more efficient earlier in its operation than previous heating facilities.

[0095] By taking into consideration more than just the outdoor temperature, the controller-determined reset curves **2150** described above are more efficient than base reset curves that are just based on outdoor temperatures. For example, a school building is unoccupied during portions of each day and certain days of each week. Internal heat gains and external heat losses will therefore vary widely over time during the day and will be different on different days of the week. For example, on Sunday at 8:00 a.m. the building is empty, the ventilation load is set to minimum, the space set point values have been lowered by the BMS. The control establishes a controller-determined reset point of 120° F. to maintain all of the space temperatures. But on Monday at 8:00 a.m. the building becomes populated, the ventilation load is set to maximum fresh air and the space set point values have been raised by the BMS. The control establishes a controller-determined reset point of 140° F. to maintain all of the space temperatures. In order to form the controller-determined reset point, bins were defined for each combination of a day of the week, a time range during the day, and an outdoor temperature range. This allows a separate controller-determined reset curve to be created for each combination of the day of the week and the time range thereby providing more accurate and more efficient reset points.

[0096] An example of a computing device that can be used as the controller **120** or the Building Management Control System **2102** to implement the functions described above is shown in the block diagram of FIG. 27. The computing device **10** of FIG. 27 includes a processing unit **12**, a system memory **14** and a system bus **16** that couples the system memory **14** to the processing unit **12**. System memory **14** includes read only memory (ROM) **18** and random access memory (RAM) **20**. A basic input/output system **22** (BIOS), containing the basic routines that help to transfer information between elements within the personal computer **10**, is stored in ROM **18**.

[0097] Embodiments described above can be applied in the context of computer systems other than personal computer **10**. Other appropriate computer systems include handheld devices, multi-processor systems, various consumer electronic devices, mainframe computers, and the like. Those skilled in the art will also appreciate that embodiments can also be applied within computer systems wherein tasks are performed by remote processing devices that are linked through a communications network (e.g., communication utilizing Internet or web-based software systems). For example, program modules may be located in either local or remote memory storage devices or simultaneously in both local and remote memory storage devices. Similarly, any storage of data associated with embodiments of the present invention

may be accomplished utilizing either local or remote storage devices, or simultaneously utilizing both local and remote storage devices.

[0098] Computer **10** further includes a hard disc drive **24**, non-volatile solid-state memory **25** an external memory device **28**, and an optical disc drive **30**. External memory device **28** can include an external disc drive or solid state memory that may be attached to computer **10** through an interface such as Universal Serial Bus interface **34**, which is connected to system bus **16**. Optical disc drive **30** can illustratively be utilized for reading data from (or writing data to) optical media, such as a CD-ROM disc **32**. Hard disc drive **24** and optical disc drive **30** are connected to the system bus **16** by a hard disc drive interface **32** and an optical disc drive interface **36**, respectively. The drives, solid-state memory and external memory devices and their associated computer-readable media provide nonvolatile storage media for the personal computer **10** on which computer-executable instructions and computer-readable data structures may be stored. Such computer-executable instructions can include instructions for performing any of the steps described in the methods above. Other types of media that are readable by a computer may also be used in the exemplary operation environment.

[0099] A number of program modules may be stored in the drives and RAM **20**, including an operating system **38**, one or more application programs **40**, other program modules **42** and program data **44**. In particular, application programs **40** can include the programs for increasing the boiler fluid set point as described above, decreasing the boiler fluid set point as described above, removing an input device from consideration when determining whether to increase or decrease the boiler fluid set point, reinstating an input device into the consideration of whether to increase or decrease the boiler fluid set point, storing boiler fluid set points and using the stored set points to create reset curves, generating logs indicating input devices that caused the boiler fluid set point to be increased, the number of times each input device caused an increase and the duration that each input device's deviation exceeded a threshold amount discussed above and program data **44** may include and stored data including boiler temperature fluid set points, counts for input devices, durations that each input device's deviation exceeded a threshold amount, days of the week, times of day, outside temperatures, and reset curves, for example.

[0100] Input devices including a keyboard **63** and a mouse **65** are connected to system bus **16** through an Input/Output interface **46** that is coupled to system bus **16**. Monitor **48** is connected to the system bus **16** through a video adapter **50** and provides graphical images to users. Other peripheral output devices (e.g., speakers or printers) could also be included but have not been illustrated. In accordance with some embodiments, monitor **48** comprises a touch screen that both displays input and provides locations on the screen where the user is contacting the screen.

[0101] The personal computer **10** may operate in a network environment utilizing connections to one or more remote computers, such as a remote computer **52**. The remote computer **52** may be a server, a router, a peer device, or other common network node. Remote computer **52** may include many or all of the features and elements described in relation to personal computer **10**, although only a memory storage device **54** has been illustrated in FIG. **27**. The network connections depicted in FIG. **27** include a local area network

(LAN) **56** and a wide area network (WAN) **58**. Such network environments are commonplace in the art.

[0102] The personal computer **10** is connected to the LAN **56** through a network interface **60**. The personal computer **10** is also connected to WAN **58** and includes a modem **62** for establishing communications over the WAN **58**. The modem **62**, which may be internal or external, is connected to the system bus **16** via the I/O interface **46**.

[0103] In a networked environment, program modules depicted relative to the personal computer **10**, or portions thereof, may be stored in the remote memory storage device **54**. For example, application programs may be stored utilizing memory storage device **54**. In addition, data associated with an application program, such as data stored in the databases or lists described above, may illustratively be stored within memory storage device **54**. It will be appreciated that the network connections shown in FIG. **27** are exemplary and other means for establishing a communications link between the computers, such as a wireless interface communications link, may be used. For example, such network connections may be used to connect the Building Management Control System to the Controller.

[0104] Computer **10** may further include interfaces for receiving signals from one or more of the input devices. These interfaces may receive wired connections or wireless connections to the input device and may receive analog values or digital values. The interfaces may include drivers that condition the signals received from the input devices to place them in a form desired by computer **10**. For example, the interface can sample an analog signal to produce a sequence of digital values.

[0105] Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

What is claimed is:

1. A system for establishing a boiler fluid set point comprising:
 - a plurality of input devices providing input values for a plurality of different portions of a heating system;
 - a controller determining that during a period of time there was always at least one input value that deviated from a set point for the input value by more than a threshold amount and in response, the controller increasing the boiler fluid set point.
2. The system of claim 1 wherein the input device comprises one of a pressure sensor and a flow sensor.
3. The system of claim 1 wherein the input device comprises a temperature sensor.
4. The system of claim 1 wherein the controller determines that during a second period of time, none of the input values deviated from their set point and in response decreases the boiler fluid set point.
5. The system of claim 4 wherein the controller only increases the boiler fluid set point if the increased boiler set point is less than an outdoor reset curve set point.
6. The system of claim 1 wherein the controller further determines a boiler fluid set point from an outdoor temperature and a temperature reset curve formed based on adjusted boiler set points.
7. The system of claim 1 wherein the system comprises a hydronic heating system that contains multiple secondary loops.

8. The system of claim 1 wherein the system calculates a net efficiency of at least one boiler.

9. The system of claim 1 wherein the controller generates a log containing a list of input devices that triggered raising the boiler fluid set point to a higher value.

10. The system of claim 9 wherein the controller records the duration that each input value deviated from its set point by more than a deviation trigger value.

11. The system of claim 9 wherein the controller records the number of times that an input device caused an increase in the boiler fluid set point.

12. The system of claim 11 wherein when the number of times the input device's input value caused an increase in the boiler fluid set point exceeds a count threshold, the controller stops using the input device's input value to determine if the boiler fluid set point should be increased.

13. The system of claim 12 wherein the controller generates a log that identifies areas associated with input devices that the controller stopped using to determine if the boiler fluid set point should be increased.

14. The system of claim 13 wherein the controller further generates a log comprising a list of input devices ranked in order based on the number of times each input device caused an increase in the boiler fluid set point.

15. The system of claim 1 wherein the controller records fluid temperatures going into and out of the boiler(s), fuel

usage, and fluid flow, and generates a log containing a boiler efficiency data and a means of establishing the boiler fluid set point.

16. A controller in a heating system changes a boiler fluid set point, stores the changed boiler fluid set point together with an outside temperature and uses the stored changed boiler fluid set point and the stored outside temperature to generate a reset curve used to establish a boiler fluid set point when starting a boiler system.

17. The controller of claim 16 wherein the controller generates the reset curve by assigning the changed boiler fluid set point to a line defined by a range of outside temperatures.

18. The controller of claim 17 wherein the line is further defined by at least one of a day of the week, a date and a time of day.

19. A controller in a heating system identifies input devices that prevent the controller from lowering a boiler fluid set point and generates a log providing a list of such input devices.

20. The controller of claim 19 wherein the log comprises the number of times the input device prevented the controller from lowering the boiler fluid set point.

21. The controller of claim 19 wherein the log comprises a period of time when an input value provided by the input device differed from a set point for the input value by more than a threshold amount.

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