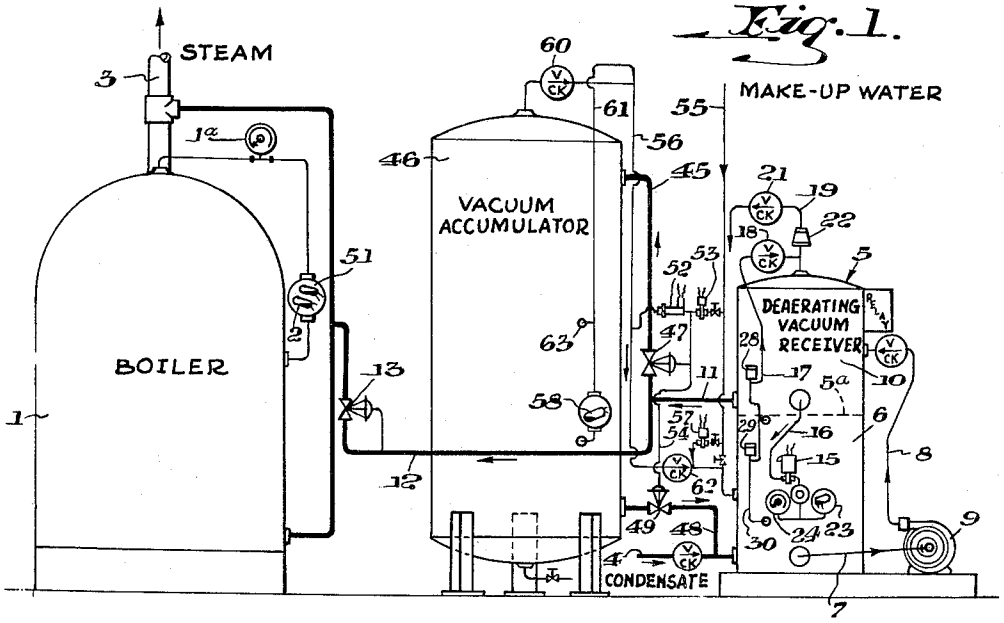
Aug. 22, 1961 C. I. BAKER 2,997,129

DEAERATION IN A STEAM HEATING SYSTEM

Filed March 27, 1959

Fig. 1.



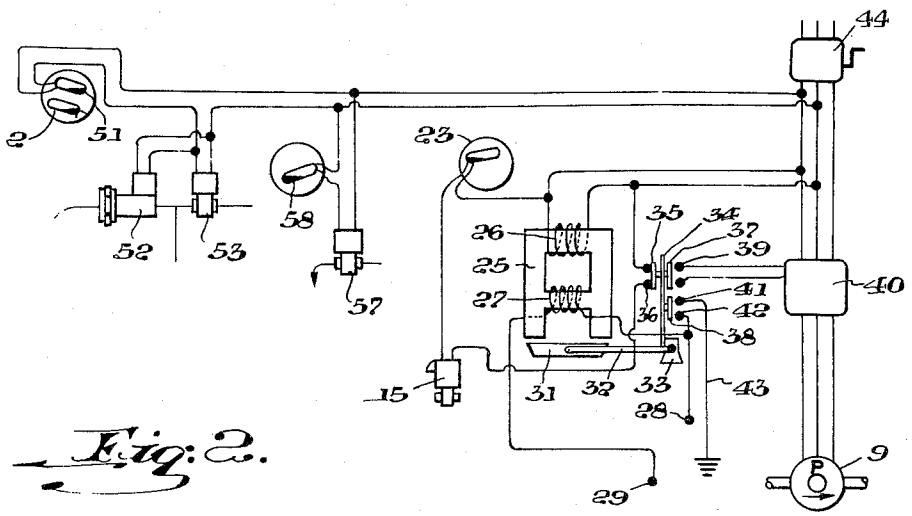


Fig. 2.

INVENTOR.
CHARLES I. BAKER.

BY
Brown, Critchlow, Flick & Peckham
his
ATTORNEYS.

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DEAERATION IN A STEAM HEATING SYSTEM

Charles I. Baker, P.O. Box 4412, Pittsburgh, Pa.

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This invention relates to steam heating systems, and more particularly to those that operate intermittently, such as only in the daytime.

In school buildings, for example, steam heating systems are heavily fired in the morning to warm the building for the children. Steam generation begins only when all the boiler water is at boiling temperature. Therefore, steam generation at full fuel rate begins all at once. As the radiators are cold when the steam first enters them, the initial condensation rate is high. Before this initial condensation can be collected and returned to the boiler, the boiler water level will fall so low that cold untreated make-up water must be added. By the time the initial condensation returns to the boiler, the radiators are heated and less steam is, therefore, being condensed. The result is that the amount of boiler water being used is reduced and the returning initial condensation tends to raise the water level too high in the boiler, so the excess must overflow or be blown out to waste. Many heating systems have make-up and waste in this manner many times a day. Also, heating systems with zone controls have makeup and waste. When a zone steam supply valve closes, a high vacuum develops within that zone and holds back the condensate, which is released only when the steam supply valve reopens. In the meantime, make-up water has to be supplied to the boiler to make up for the condensate that is being held back. The result of all this is that fuel as well as water is wasted, and the untreated make-up water brings into the system corrosive gases that accelerate its corrosion.

It is among the objects of this invention to provide in a steam heating system a method and apparatus which deaerates all water entering and within the system, which greatly minimizes the use of makeup water, which stores extra water in the system itself, which reduces fuel expense and corrosion of the system apparatus, which creates a high vacuum in the condensate return line of the system, which maintains boiler water level without auxiliary power units, which requires only one pump, and which removes heavy as well as light gases from the system.

In accordance with this invention, the condensate of steam that was used in heating a given area is conducted away from that area to a location where it is deaerated. The deaerated condensate then is delivered to a storage point in the system until needed. When the boiler that generates the steam needs more water the stored condensate is drawn to the deaerating location and from there is pumped to the boiler to bring the water level back up to the proper level. With this system there always is enough deaerated water in storage to keep up the boiler water level when the system radiators are cold. When they become warm and less water is used, the condensate accumulates in storage, where further deaeration takes place. A single pump can be used for creating the deaerating vacuum and the power movement of condensate in the system.

The preferred embodiment of the invention is illustrated in the accompanying drawings, in which

FIG. 1 is a somewhat diagrammatic side view of my apparatus; and

FIG. 2 is an electric wiring diagram of the system.

Referring to FIG. 1 of the drawings, water in a boiler 1 is heated by a suitable burner, not shown, the fuel for which is shut off by a float switch 2 in case the water

level in the boiler becomes dangerously low. The steam pressure in the boiler is indicated by the gauge 1*a*. Steam generated in the boiler leaves through a pipe 3 that conducts it to the various system radiators (not shown) in the area to be heated, where the steam is condensed and then the condensate is led back toward the boiler through a return line 4. Before reaching the boiler, the condensate passes through a deaerating vacuum receiver 5, in which the water is partly deaerated. The desirability of deaeration is well known and need not be explained here, except to point out that corrosion in a steam heating system is directly proportional to the available oxygen in the system. The deaerating receiver may take various forms, but preferably is made in two sections or tanks, both of which may be housed in a single unit. The receiver shown has a lower inlet tank 6 that receives condensate from the return line 4. This tank is connected by pipes 7 and 8 and a pump 9 with an outlet tank 10 in the upper part of the receiver. The two tanks are separated by a partition wall 5*a*. The lower part of the outlet tank is connected by a discharge pipe 11 and a branch pipe 12 with the boiler inlet. The branch pipe is provided with a normally closed diaphragm valve 13, which can be opened only when the water pressure in that pipe rises to a point where it will press against the valve diaphragm with sufficient force to open the valve.

While the system is in operation and the receiver is idle, condensate from the return line collects in the bottom of the receiver until its lower tank 6 is completely filled and the condensate level is a few inches higher. Then, through an electric circuit that will be described presently, the pump is started in operation to pump condensate from the lower tank to the upper tank of the receiver. Since the lower tank is sealed at this time, except for the opening from the return line 4, the moment the liquid level in that tank starts to fall, a high impulse vacuum suddenly will be produced that will draw trapped gases and stalled condensate from the return line into the receiver. In fact, the turbulence caused by the activity of the high impulse vacuum will move any sediment out of the return line and into the receiver, thereby keeping the condensate return line clean.

The pump will continue to run until the water level in the lower tank has fallen to a predetermined lower level, at which time the pump will be shut off and a normally closed return valve 15 in a drain pipe 16 connecting the lower part of the upper tank with the lower tank will be energized and opened. Condensate that was pumped into the upper tank of the receiver now will return by gravity through drain pipe 16 to the lower tank, thereby forcing the gases, with which the lower tank was partly filled, up through a gas pipe 17 connecting the top of the lower tank with the upper part of the upper tank. This pipe contains a check valve 18 that is closed while condensate is being pumped out of the lower tank. Since the lower tank has again been filled with water from the upper tank, return valve 15 is closed as the pump starts operating and again begins moving condensate from the lower to the upper tank. This displacement will continue until a second predetermined volume of gases is received by the lower tank from the return line. During this period the condensate being pumped into the upper tank forces out of it through a top vent 19 the gases that were forced into it from the lower tank while return valve 15 was open.

In other words, as gas pressure builds up in the upper tank, due to the entering condensate from the pump, the gases start to discharge slowly to atmosphere through a small check valve 21 in the vent. That valve restricts the discharge so that the gas pressure becomes practically the same on top of the disc of an inverted vertical check

valve 22 as below it, and that valve remains open to discharge of gases. On the other hand, when the condensate level in the upper tank, which rises quite rapidly, reaches valve 22, the force of the liquid will close the valve and prevent the water from escaping through the vent. Any condensate that is pumped into the upper tank after valve 22 has been closed causes an equal quantity to be discharged through the discharge pipe 11.

This repeated cycle of power and gravity displacement of condensate from one tank to the other creates vacuum in the lower tank and return line 4, separates corrosive gases from the condensate, discharges those gases to the atmosphere and pumps excess condensate out of the receiver through pipe 11. Such liquid displacement back and forth between the tanks continues until sufficient vacuum has been created in the return line and lower tank to open a vacuum control switch 23 in the piping below return valve 15. Now when electric current is switched from the pump to the return valve circuit, open switch 23 will prevent that valve from being electrically energized and opened. Condensate will be detained in the upper tank until a predetermined reduction in vacuum permits the vacuum switch to close in order to open the return valve and allow condensate to drain into the lower tank from the upper one. The degree of vacuum in the lower tank is shown by a vacuum guage 24.

A definite quantity of condensate is required for the power and gravity displacement operations in the receiver. During those operations, condensate is withdrawn from the return line. The additional condensate thus received becomes excess and an equal quantity therefore is discharged from the upper tank through pipe 11.

The circuit for controlling the pump and return valve is shown in FIG. 2. It includes a relay having a laminated core 25 that is formed from upper and lower cross bars between legs that project below the lower bar. Encircling the upper bar is a primary coil 26 that is always in the power circuit. The lower bar of the core is encircled by a secondary coil 27, the ends of which terminate in electrodes 28 and 29 that are exposed to the condensate in the two tanks of receiver 5 and are simply elements that will conduct electricity. The higher electrode 28 may be located in gas pipe 17 connecting the two tanks and in which condensate also rises, and the lower electrode 29 may be exposed to water in a pipe 30 (FIG. 1) connecting pipe 17 with the lower portion of the lower tank. An armature 31, normally lying slightly below core 25 is pivotally connected to one end of a lever 32, the opposite end of which is pivotally mounted in a suitable support 33. Projecting upward from this lever is an insulated arm 34 that carries on one side a switch bar 35, which normally engages a pair of contacts 36 in a circuit connecting return valve 15 and normally closed switch 23 with the primary coil circuit. The insulating arm carries on its opposite side a pair of switch bars 37 and 38, the first of which normally is spaced from contacts 39 in the coil circuit of a starter 40 for the pump motor, the other bar normally being spaced from another pair of contacts 41 and 42. Contact 41 is grounded to the receiver by means of a wire 43. The other contact 42 is connected with the upper electrode 28 of the secondary coil. Element 44 is an ordinary line switch.

Alternating current in the primary coil sets up a magnetic flux which, following the lines of least resistance, circulates through the shortest path in the core. This is through the two cross bars and the connecting portions of the legs. The flow of magnetic flux induces a voltage in the secondary coil, but no current flows in that coil until its circuit is closed. The secondary coil circuit is closed only when the condensate level rises high enough in the receiver to contact the two electrodes 28 and 29 and thereby electrically connect them to complete the circuit. Thereupon, a bucking action is set up in the lower bar of the core because of the flow of current in the secondary circuit. This bucking action tends to divert the lines of magnetic force from the lower bar to the projecting portions of the legs of the core and thereby sets up a strong magnetic attraction which pulls the armature up into contact with the legs. This movement of the armature swings arm 34 to first open the return valve circuit so that the valve will close, and then to close the motor starter switch. At the same time the switch connecting the upper electrode 28 with ground is closed, so that a holding circuit is formed to maintain the relay armature closed after the water level falls below electrode 28 and until it also falls below the lower electrode 29 and thereby opens the secondary coil circuit. As soon as the secondary coil circuit is opened in this manner, the armature drops, the return valve switch 36 is closed to open that valve, and the holding switch and pump motor switch are opened.

The discharge pipe 11 from the upper tank of the deaerating vacuum receiver also is connected by a branch pipe 45 to the upper part of a vacuum accumulator 46, which is a storage and additional deaerating tank for excess condensate in the system. This branch pipe is provided with a normally open diaphragm valve 47. The bottom of the accumulator is connected by a pipe 48, containing a normally closed diaphragm valve 49, with the lower part of the receiver. Since valve 13 normally is closed, condensate being pumped out of the receiver normally is delivered to the vacuum accumulator through pipes 11 and 45. However, whenever the water level in the boiler falls below a certain point, the boiler will call for water and valves 47 and 49 will be reversed as explained in the next paragraph so that the condensate discharged from the receiver will build up sufficient pressure behind valve 13 to open it and allow the condensate to be delivered to the boiler through pipe 12. At the same time, the condensate in the receiver will be replenished by condensate drawn into it from the accumulator through pipe 48, due to the high vacuum in the receiver.

This reversal of valves 47 and 49 is initiated by a float switch 51 controlled by the level of the water in the boiler. As long as the level is as high as it should be, the switch is open and a control valve 52 remains open while another control valve 53 remains closed. These two valves are connected by a pipe 54 with the diaphragm valves 47 and 49, and valve 53 is connected with a make-up water supply line 55. The other control valve connects pipe 54 with a gas pipe 56 leading from the top of the accumulator to the lower tank of the receiver. When the water level in the boiler falls and closes float switch 51, the electric circuit thus established, as shown in FIG. 2, causes control valve 52 to close and the other control valve to open to allow water pressure from the supply line 55 to close the upper diaphragm valves 53, 47 and open the lower diaphragm valve 49. When the boiler water comes back up to level and the float switch opens again, control valve 53 closes and the other control valve 52 opens so that the pressure in pipe 54 will be relieved and the two diaphragm valves can switch back to their normal positions. Thus, a sufficient reserve of water for peak steam demand is stored in the accumulator, to which condensate is returned when the demand decreases.

The make-up water line 55 is also connected with the lower part of the receiver, but normally is shut off by an electric valve 57. If water in the entire system starts to become too low, the condensate level in the accumulator will fall to such a point that a float switch 58 will close and cause valve 57 to open and replenish the supply. It will be observed that the make-up water does not go directly to the boiler, however, but first passes through receiver 5 where it is deaerated.

The gas pipe 56 connecting the top of the accumulator with the bottom of the receiver permits the receiver to

draw the lighter gases out of the accumulator and thereby create a vacuum in it. A check valve **60** in the gas pipe near the top of the accumulator prevents flow in the opposite direction, so vacuum is maintained in the accumulator even when the lower tank of the receiver is refilled with condensate. This vacuum in the accumulator causes further deaeration of the condensate in the accumulator, in which a higher average vacuum is maintained than in the receiver. It has been found that the heavy gases on the surface of the water in the accumulator are never removed unless by overflow of water therefrom. If there is no automatic means to remove these corrosive gases, they are absorbed as the condensate cools. To overcome this difficulty, a gas pipe **61** is connected to the accumulator about half way down its side and is also connected with the lower part of the receiver, such as through the other gas pipe **56**. Pipe **61** also is controlled by a check valve **62**, which may be located in pipe **56** near the receiver to prevent water from rising in that pipe. When the water level falls below the inlet **63** of pipe **61**, the heavy gases in the accumulator will be drawn out because check valve **60** is loaded slightly and therefore will not open until the water level again rises above pipe inlet **63**.

By the use of the vacuum accumulator, better deaeration is obtained and water and fuel are not wasted, because water that is needed only intermittently, is stored in the accumulator until needed and is returned to it when no longer required. Moreover, any make-up water that enters the system is deaerated before going to the boiler. All of the power for positively moving the water in the system is furnished by a single pump.

According to the provisions of the patent statutes, I have explained the principle of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. Deaerating apparatus comprising a deaerating receiver having an inlet tank and an outlet tank, the inlet tank having a condensate inlet for connection to a condensate return line, the outlet tank having a condensate outlet, means for pumping water from the inlet tank to the outlet tank to create a vacuum in the inlet tank and to discharge water from said outlet, means for discharging to atmosphere gases separating from the water in the receiver, an accumulator provided with an inlet and an outlet for condensate, a conduit connecting said receiver outlet tank outlet with the accumulator inlet for storing water in the accumulator, a normally open valve in said conduit, a second conduit connected with the accumulator outlet and receiver inlet tank for returning water to the receiver inlet tank, a normally closed valve in the second conduit, the accumulator having a gas outlet in its top, a pipe connecting the receiver inlet tank to said gas outlet to create a vacuum in the accumulator, a check valve in said pipe permitting flow only toward the receiver, a third water conduit adapted to connect the receiver outlet tank to a boiler, and means for opening said normally closed valve and closing said normally open valve so that water from the accumulator will be drawn through said second conduit into the receiver and water in the receiver will be delivered through said third conduit.

2. Apparatus according to claim 1, in which said receiver outlet tank is above the inlet tank, a gas conduit connects the top of the lower tank with the top of the upper tank, a check valve in said gas conduit prevents

flow of gas downward therein, a drain conduit connects the upper tank to the lower tank, a valve is in said drain conduit and is open while the pump is idle, and means responsive to a predetermined high water level in said receiver closes the drain valve and sets the pump in operation until the water level in the lower tank falls a predetermined amount.

3. Apparatus according to claim 2, in which said last-mentioned means includes an electric relay having a continuously energized primary and a normally open secondary circuit that is closed when said high water level is reached, and closing of the secondary circuit causes said closing of the drain valve and operation of the pump.

4. Apparatus according to claim 1, including a second pipe connecting a low level gas outlet from said accumulator to the receiver inlet tank, a check valve in said second pipe permitting flow only toward the receiver, said first-mentioned check valve being loaded so that when the condensate level in the accumulator falls below said low level gas outlet the heavy gases on the surface of the condensate will be withdrawn through said second pipe.

5. Apparatus according to claim 1, including a normally closed valve in said third water conduit having pressure responsive means for opening it, and means placing said pressure responsive means in communication with condensate in the receiver for actuation thereby when the pressure thereof reaches a predetermined maximum.

6. Deaerating apparatus comprising a deaerating receiver having an inlet tank and an outlet tank, the inlet tank having a condensate inlet for connection to a condensate return line, the outlet tank having a condensate outlet, means for pumping water from the inlet tank to the outlet tank to create a vacuum in the inlet tank and to discharge water from said outlet, means for discharging to atmosphere gases separating from the water in the receiver, an accumulator provided with an inlet and an outlet for condensate, a conduit connecting said receiver outlet tank outlet with the accumulator inlet for storing water in the accumulator, a normally open valve in said conduit, a second conduit connected with the accumulator outlet and receiver inlet tank for returning water to the receiver inlet tank, a normally closed valve in the second conduit, the accumulator having a gas outlet in its top, a check valve connected with said gas outlet and permitting flow only out of the accumulator, a pipe connecting a low level gas outlet from said accumulator to the receiver inlet tank, a check valve in said pipe permitting flow only toward the receiver, said first-mentioned check valve being loaded so that when the condensate level in the accumulator falls below said low level gas outlet the heavy gases at the surface of the condensate will be withdrawn through said pipe, a third water conduit adapted to connect the receiver outlet tank to a boiler, and means for opening said normally closed valve and closing said normally open valve so that water from the accumulator will be drawn through said second conduit into the receiver and water in the receiver will be delivered through said third conduit.

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