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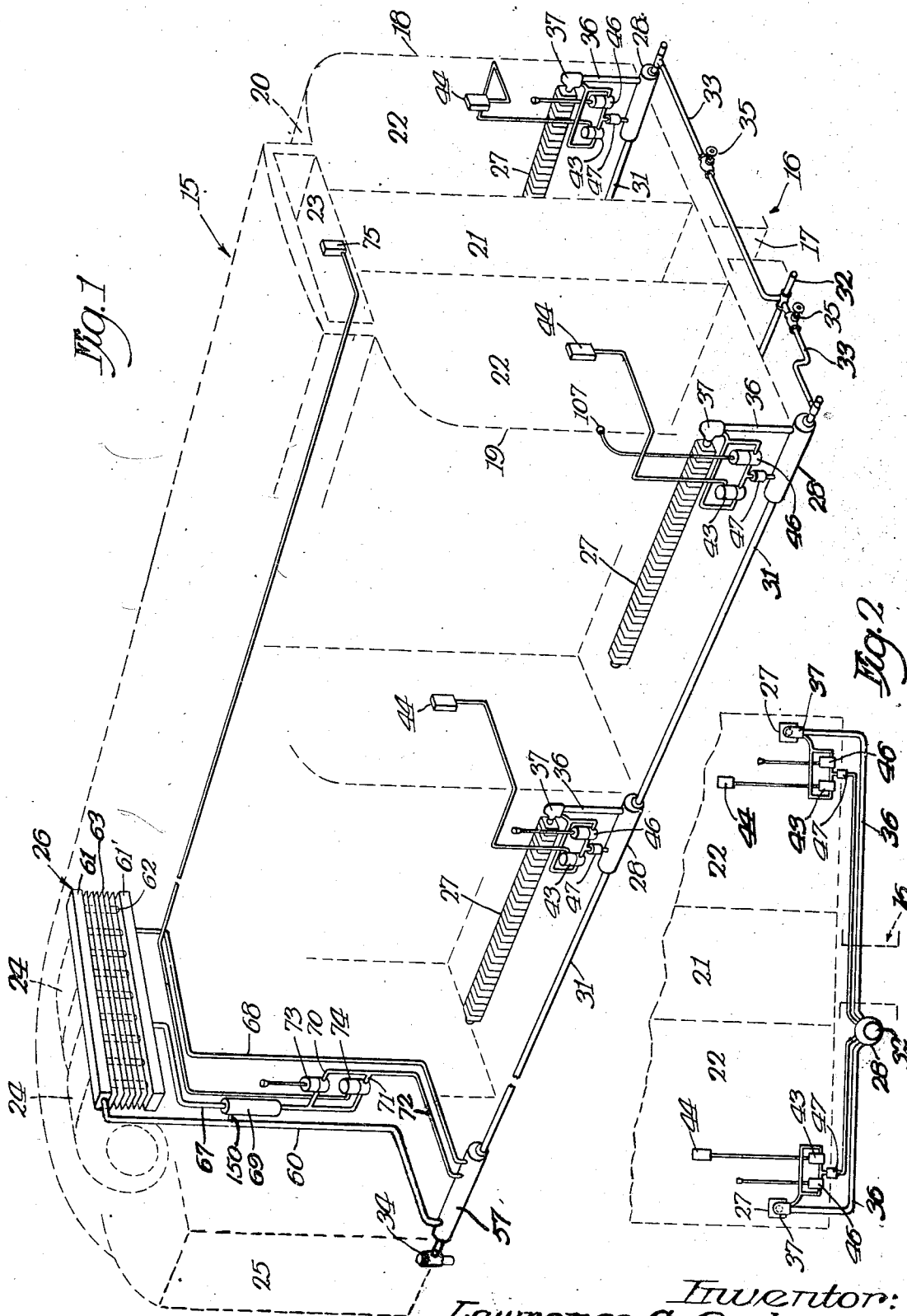
L. C. ANDERSON

HEATING SYSTEM

2,307,723

Filed May 11, 1939

5 Sheets-Sheet 1



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Jan. 5, 1943.

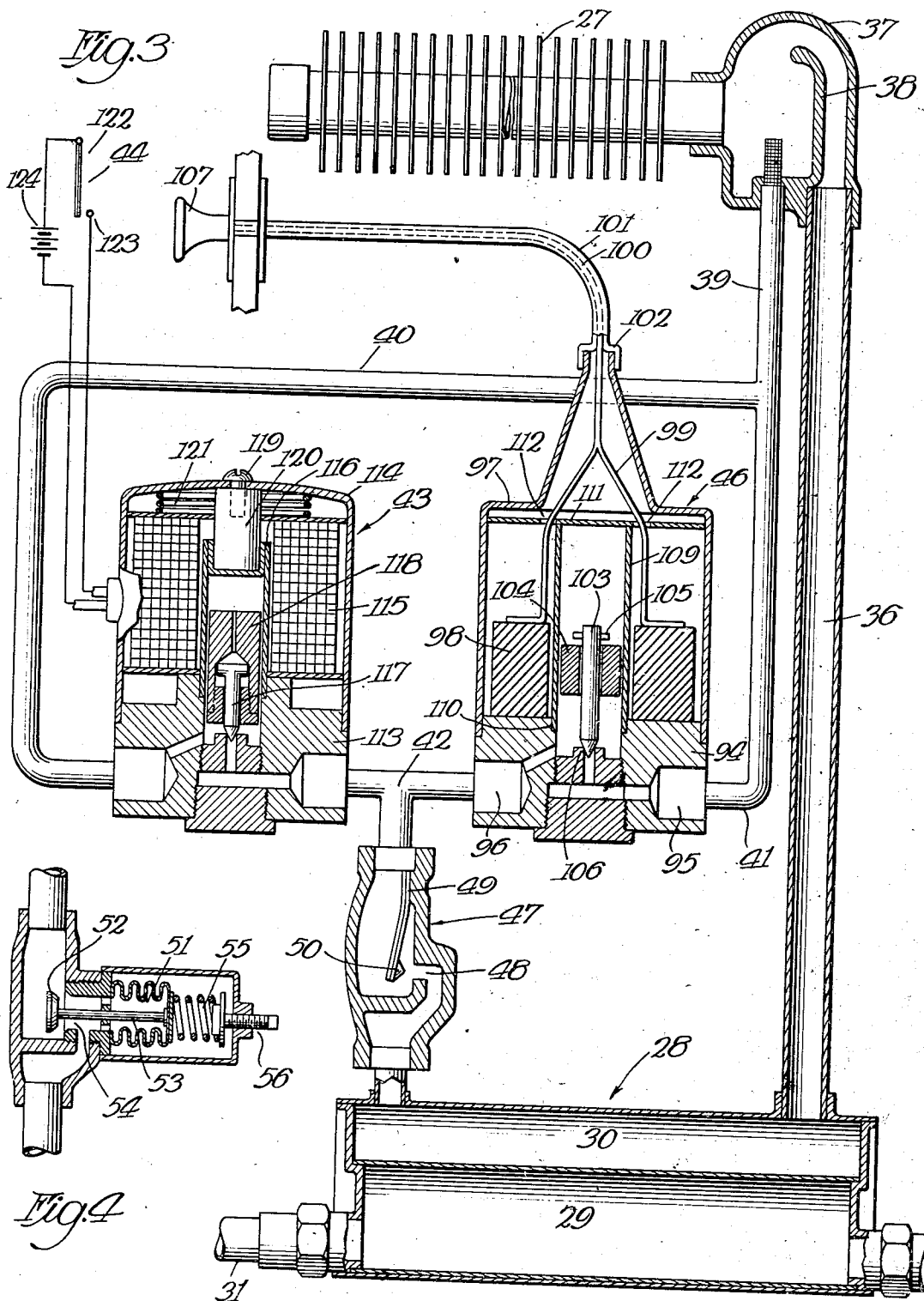
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HEATING SYSTEM

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5 Sheets-Sheet 2



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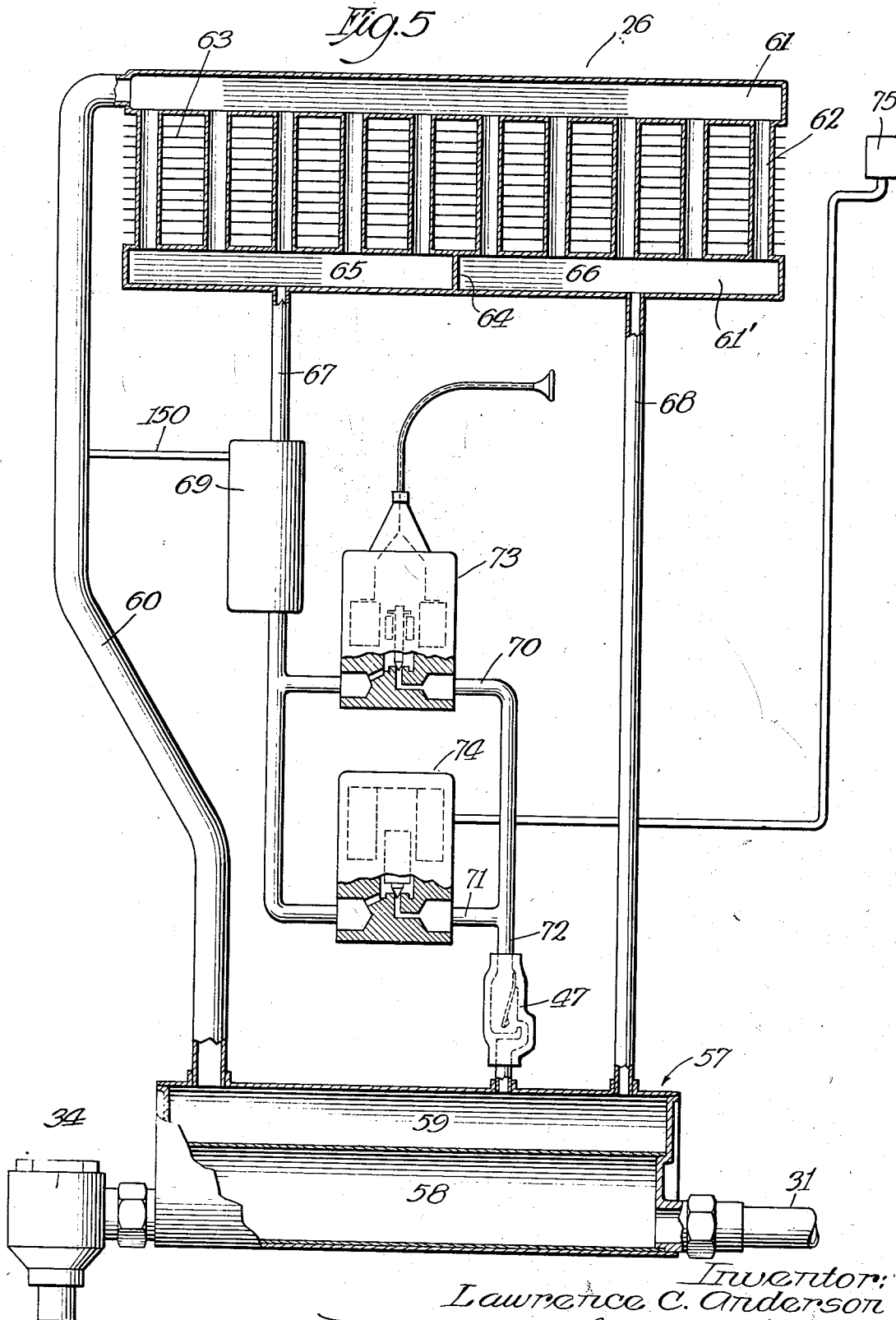
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HEATING SYSTEM

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5 Sheets-Sheet 3



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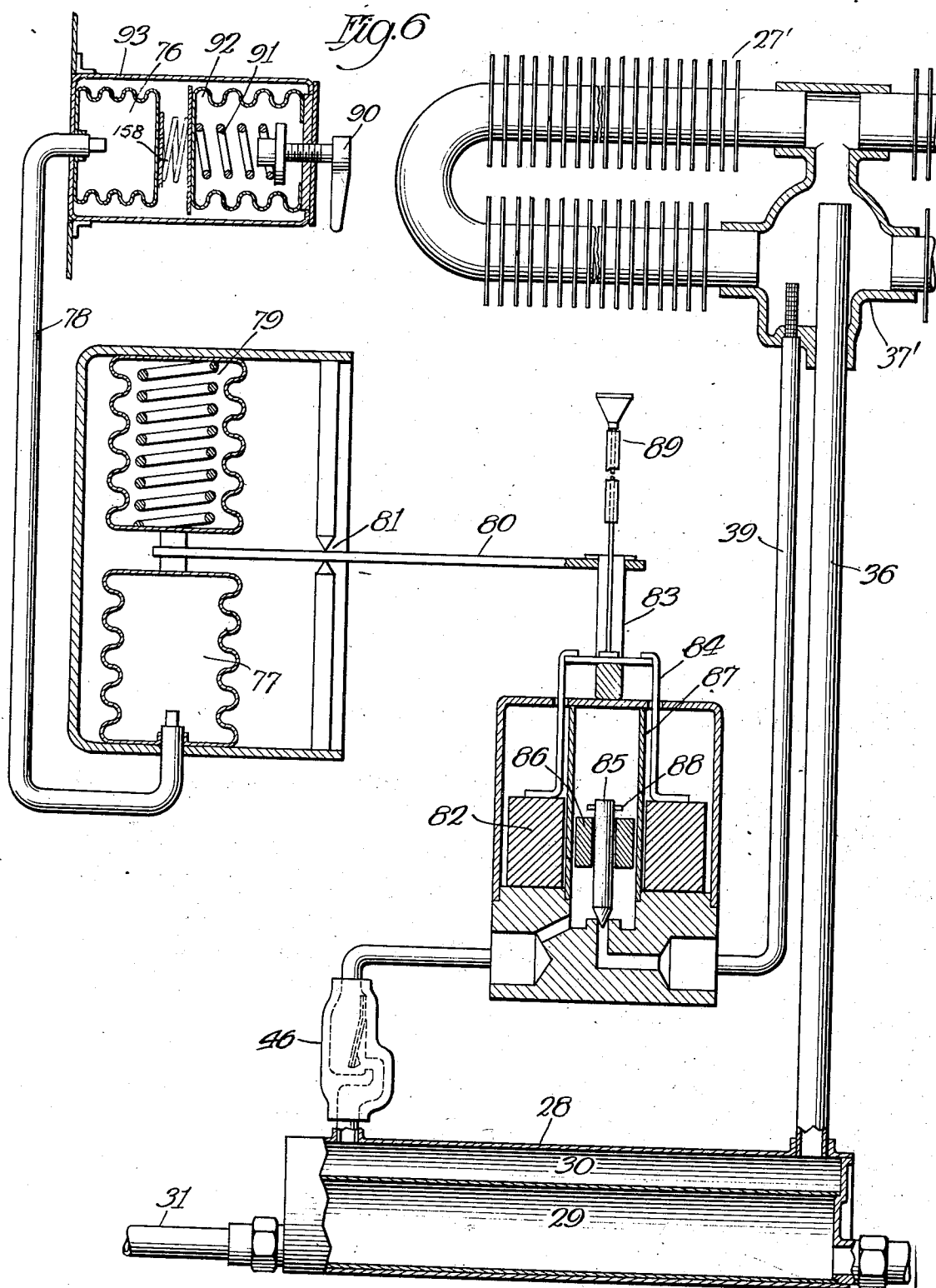
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HEATING SYSTEM

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5 Sheets-Sheet 4



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HEATING SYSTEM

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5 Sheets-Sheet 5

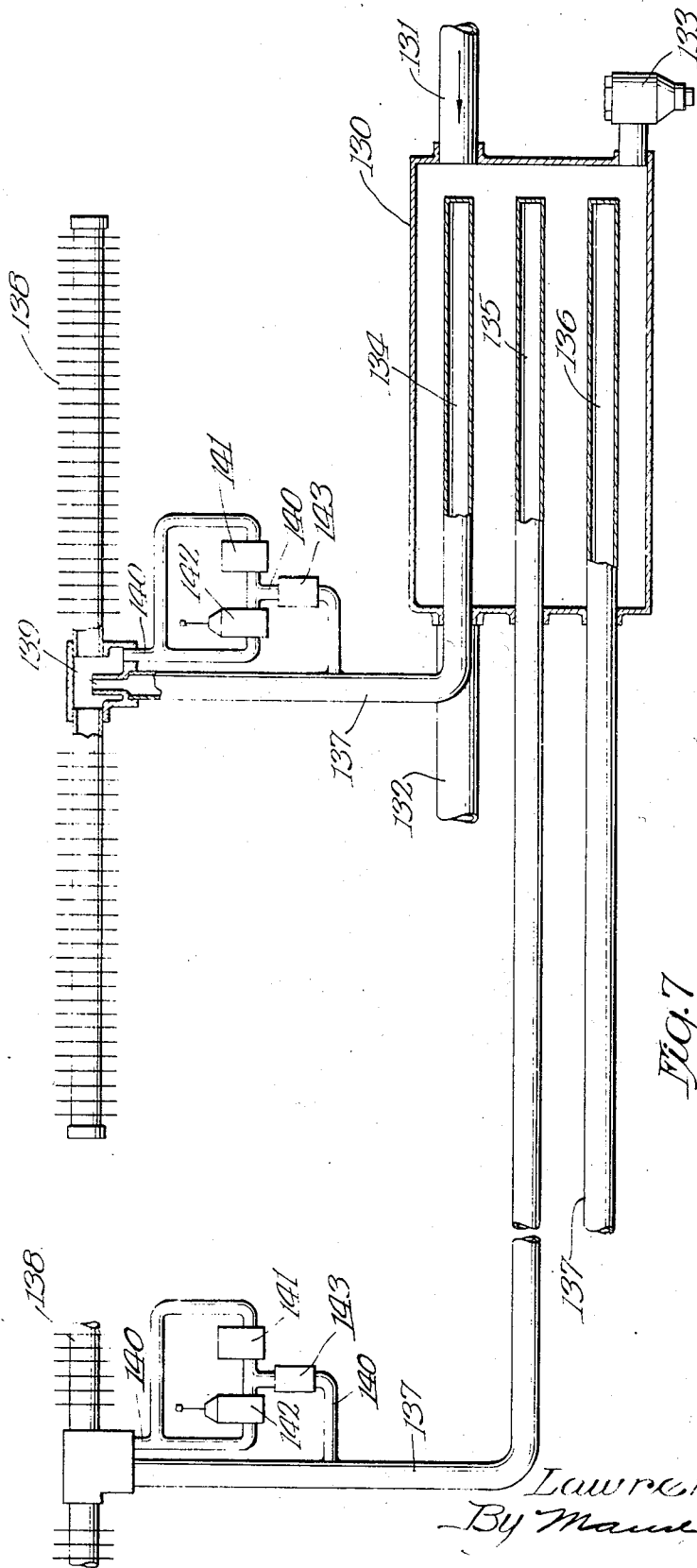


Fig. 7

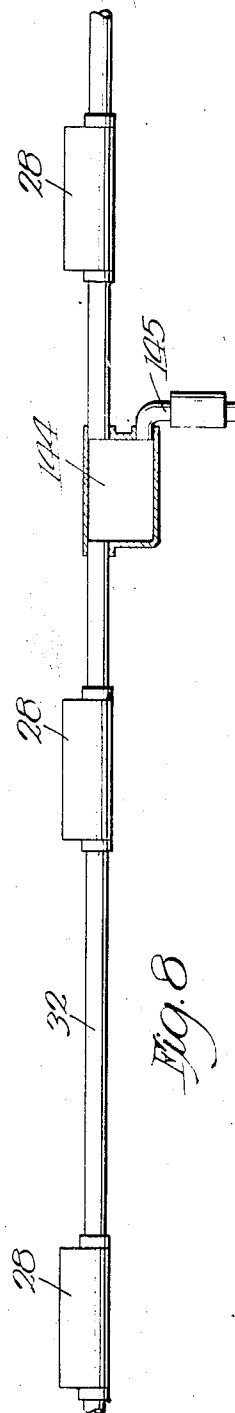


Fig. 8

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UNITED STATES PATENT OFFICE

2,307,723

HEATING SYSTEM

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Application May 11, 1939, Serial No. 273,138

16 Claims. (Cl. 237-6)

Among the principal objects of the present invention are the following: To provide an entirely automatic modulating heating system for a vehicle which maintains uniform temperatures throughout the vehicle when the heating system is in operation; to provide a highly flexible, safe, and easily controlled heating system which responds quickly to heat demands; and to provide simple and highly effective means for controlling a heating system of this type.

Further and other objects and advantages will become apparent as the disclosure proceeds and the description is read in conjunction with the accompanying drawings, in which—

Fig. 1 is a diagrammatic perspective view of a portion of a rail car showing the heating system;

Fig. 2 is a fragmentary sectional view taken through a car showing the heating system employing a modified form of boiler arrangement the car being indicated in broken lines;

Fig. 3 is an enlarged view of the floor heating system and controls for same;

Fig. 4 is an enlarged detail view of a safety valve suitable for use in the heating system, the valve being different from the one shown in Fig. 3;

Fig. 5 is an enlarged view of the overhead modulating heating system, including the controls for same;

Fig. 6 is an enlarged view of the floor heating system in which the thermostatically and manually controlled valves shown in the previous figures are included in one valve unit;

Fig. 7 is a view of a modified form of the present invention showing in section a boiler having a plurality of secondary chambers; and

Fig. 8 is a side elevational view of a portion of the steam line under the car showing a plurality of boilers mounted in place and a steam trap between two of the boilers.

In compliance with section 4888 of the Revised Statutes, specific embodiments of the present invention have been selected for the purpose of disclosure, but it is intended that the appended claims shall be construed as broadly as the prior art will permit.

Referring now to Fig. 1, a railway car 15 is shown having an underframe, generally indicated at 16, including a center sill 17, a pair of side frames 18 and 19, and a roof 20. Passing along the center of the car is an aisle 21, on each side of which are rooms 22. Directly over the aisle is a duct 23 extending the full length of the car, and its purpose is to provide car ventilation.

At one end of the car and adjacent to the

roof are positioned blower fans 24 which draw air from the car vestibule 25 and discharge into the overhead duct 23. Situated on the discharge side of the blower fans 24 and in the overhead duct 23 is an overhead heat radiator 26 for providing overhead heat to the car interior.

In each room 22, floor heating coils 27 are provided, which serve as auxiliary heating units to remove the drafts from the floor area and supplement the overhead heat. Each of the floor heat radiators 27 is connected to a boiler 28, which, in turn, comprises primary and secondary chambers 29 and 30 respectively (Fig. 3).

As shown in Fig. 1, the boilers 28 are mounted on a pipe line 31, which, in turn, is fed by steam from the train line 32 through transversely extending pipes 33. The steam is fed to the primary chamber 29 in each boiler, and at the far end of the last boiler, mounted on pipe line 31, is a steam trap 34 for removing condensate from the system. Between the steam train line 32 and the boilers 28 are valves 35 for manually controlling the flow of steam into the heating system.

As shown in Fig. 1, the boilers are mounted on a secondary pipe line 31, which extends adjacent to the side of the car parallel to the train line 32. However, as indicated in Fig. 2, it may be desirable to mount the boilers 28 directly on the train line 32.

Extending upwardly from each of the boilers 28 for the floor heating coils 27 is a riser 36 opening into the secondary chamber 30 of the boiler and secured at its upper end to the floor radiator 27 by a joining member 37. In the joining member 37, a wall 38 projects upwardly from the riser 36 to provide a passage to the top of the member 37. Extending downwardly from the joining member 37 is a return line 39, which empties into the secondary chamber 30 of the boiler; and, between the member 37 and the secondary chamber 30, the return line is split to form two parallel paths 40 and 41, which again join at 42 to empty into the secondary chamber 30. Thus, the floor heating system includes the primary heating chamber 29 of the boiler and a closed vapor heating system, including the secondary chamber 30, riser 36, floor heat radiator 27, and the return line 39 with its two parallel branches 40 and 41. A volatile liquid is placed in the closed vapor heating system and serves as the agent for transferring heat from the primary chamber 29 of the boiler to the radiator 27. Chamber 30 of the boiler is in heat exchange relationship with respect to chamber 29, so that any liquid vapor in chamber 30 comes

in contact with the hot walls of chamber 29, becomes vaporized, and ascends through riser 38 into the radiator 27. The transfer of the heat from the vapor in radiator 27 to the room to be heated causes condensation of the vapor which flows through return and branch lines 39 and 40 respectively to the valve 43, which, if open, permits the condensate to flow back to the secondary chamber 30. Valve 43 responds to the operation of a room thermostat 44; and, when room heating is not required, valve 43 closes to trap the condensate in branch line 40, thereby preventing the liquid ethyl alcohol from returning to the secondary chamber 30 of the boiler. In this manner, room heating ceases.

A manually controlled valve 46 is placed in the second branch line 41 of the return line 39, this valve being normally in a closed position. If, however, valve 43 is closed and for any reason the occupant of the room desires room heating, he operates valve 46 manually to allow the liquid ethyl alcohol to return through branch line 41 to the secondary chamber 30 of the boiler.

In the operation of this type of heating system, there is considerable danger of attaining excessive pressures in the vapor system. Consequently, a safety shut-off valve 47 is provided in the return line to the boiler. This valve has a port 48 for permitting passage of the condensate and a bimetallic strip 49 having a valve 50 at its free end for closing off the passage 48 when excessive temperatures cause the bimetallic strip 49 to bend toward the passage 48. This form of safety valve operates in response to excessive temperatures of the ethyl alcohol in the vapor heating system, but, as shown in Fig. 4, a valve responsive to excessive pressures is equally suitable. In this type of valve, a bellows 51 operates a valve member 52 through valve stem 53 to close the passage 54, through which the condensate flows in returning to the secondary chamber 30 of the boiler. The bellows 51 is backed by a coil spring 55, whose tension is initially adjusted by manipulation of a threaded bolt 56 to operate in response to a predetermined pressure. If this predetermined pressure is reached in the vapor heating system, the resistance of spring 55 is overcome by the pressure in the bellows 51, thereby expanding the bellows and closing the passage 54 to restrict the flow of condensate back to the secondary chamber 30 of the boiler.

The overhead radiator 26 is connected to the boiler 57 (Figs. 1 and 5), having a primary chamber 58 and a secondary chamber 59, the latter of which is connected by means of a riser 60 onto the radiator 26. As best shown in Fig. 5, the radiator comprises an upper and lower header 61 and 61' respectively, connected by vertical pipes 62, the latter of which are surrounded by fins 63 to provide large radiating surfaces. The lower header 61' is separated at the center by a partition 64 so that this header is divided into two separate chambers 65 and 66. A pair of return lines 67 and 68 extend from chambers 65 and 66 respectively of the radiator 26 to the secondary chamber 30 of the boiler, and a receiver 69 is positioned in the return line 67. On the discharge side of this receiver, return line 67 branches out to form two parallel lines 70 and 71, which merge again into a common return line 72 before discharging into the secondary chamber 30 of the boiler. A manually controlled valve 73 is located in the branch line 70 of the return line, and a thermostatically controlled valve 74 is placed in the branch line

71 of the return line. Manually controlled valve 73 is normally closed, so that the normal operation of the heating system is controlled by thermostatically operated valve 74.

Some suitable volatile liquid, such as ethyl alcohol, is employed in the closed vapor heating system for transferring heat from the primary chamber 58 to the radiator 26; and, as this liquid comes in contact with the hot walls of chamber 58, it vaporizes and ascends through vertical riser 60 and is discharged into the top header of the radiator 26. The vapor is then cooled by contacting the colder surfaces of the radiator and descends through pipes 62, condensing in the lower header 61, a portion of the total charge collecting in chamber 65 and the remainder in 66, so that a portion only of the total charge of volatile liquid is under the control of the valves 73 or 74 after the system is once placed into operation until such time as all of it has again been collected in the return line 67.

Valve 74 responds to the action of an overhead thermostat 75 located in the overhead heating duct (Fig. 1); and, when car heating is required, the valve 74 opens the passage through the branch line 71 to permit the volatile liquid to flow from the receiver 69 through the safety valve 47 into secondary chamber 59 of the boiler 57. When heat is no longer required, the valve 74 closes, and that portion of the condensate collecting in chamber 65 of the radiator 26 is trapped in the receiver 69, while the remainder of the condensate collecting in chamber 66 returns to the boiler through return line 68. In this way, when the thermostat 75 ceases calling for heating, the system shuts off gradually, thereby producing a modulating heating effect.

Should the occupant of the room desire heat at a time when the thermostat is not calling for heat, manipulation of the hand operated valve 73 opens the return line through branch passage 70 to place the heating system into operation.

In the modified form of the invention shown in Fig. 6, the thermostatically and manually controlled valves are incorporated into one valve unit. In this arrangement, the thermostat comprises a bellows 76, which responds to room temperature conditions to regulate the liquid pressure in bellows 77. The liquid employed is some light oil which fills the tube 78 connecting the two bellows 76 and 77. The expanding and contracting of bellows 77 against the resistance of a spring 79 operates a lever 80, which is fulcrumed at 81, to move the permanent magnet 82 through an arm 83 and magnet supporting member 84. In this form, the return line 39 is not divided into parallel paths, as is the form shown in Fig. 3, but instead it passes directly to the boiler 28. A valve stem 85 is bounded by soft iron blocks 86, which are in the form of a ring surrounding the valve member 85 and serve as the armature in the field of the magnet 82. A sleeve of non-magnetic material 87 surrounds the armature 86 and provides a restricted area in which the armature operates. When the magnet 82 is raised in response to the thermostat 76, the armature 86 follows the movement of the magnet; and, when it strikes outwardly projecting lugs 88 on the valve member 85, it raises this member from the valve seat to open the passage from the radiator 27' to the boiler.

The thermostatic element per se shown in Fig. 6 forms no part of the present invention. There are many forms of adjustable thermostats

that would serve equally well, but the one shown is simple and is suitable for illustration purposes.

The thermostatic bellows 76 is adjusted by manipulating the lever 90, which operates against a spring 91 to expand or contract bellows 92; and the variance in the displacement of a gas in housing 93, which contains both the bellows 76 and 92, varies the initial setting of the bellows 76. A spring 158 may be required between bellows 92 and bellows 76 to effect the adjustment of bellows 76 by movement of bellows 92.

If for any reason the occupant of the room wishes to control the operation of the heating system at a time when the car thermostat is not calling for heating, he raises the magnet 82 by means of the manual control arm 89, which is connected to the magnet supporting frame 84. This manual operation is entirely independent of the thermostatically controlled means.

In the form of the invention shown in Fig. 6, the radiator 27' is in the form of a closed coil; and the joining member 37' in this instance is in the form of a T. The operation of this radiator, however, in the vapor heating system is identical to the form shown in Fig. 3. The manually controlled valve shown in Figs. 3 and 5 comprises a base 94, having an intake port 95, an outlet 96 with a passage connecting the two, a housing 97 secured to the base 94 and sealed at its point of juncture, a permanent magnet 98, and a magnet supporting member 99 to which is attached a flexible cable 100 surrounded by a casing 101. The housing 97 is sealed at the top, as indicated at 102. A valve stem 103 is surrounded by a soft iron ring 104, which in turn serves as the armature in the magnetic field. A pair of lugs 105 project outwardly at the top of the valve stem 103, so that, when the armature 104 is raised by movement of the magnets 98, it contacts the lugs 105 to raise the valve stem off the valve seat 106. When it is desired to open the valve, the knob 107, which is situated in the room to be heated, is manually pulled, which raises permanent magnet 98, thereby causing the armature 104 to follow the upward movement of the magnet 98 to raise the valve stem 103 and open the passage through the valve. In this way, the heating system is manually controlled at times when control of the heating system is desired before the thermostat functions.

Between the permanent magnet 98 and the armature 104, a non-metallic tube 109 is inserted and sealed into the valve base at 110; and across the top of this member a plate 111 is placed, completely covering the tube 109, to seal the valve stem in the tube 109. The magnet supporting frame 99 operates through slots 112 in the plate 111. It is to be noted that the manual control valve is completely sealed, so that the difficulties caused by the presence of dust and dirt on the valve seat are entirely eliminated.

The thermostatically controlled valve 43 (Fig. 3) comprises a base 113, through which the ports pass, a housing 114 sealed to the base, an electromagnet 115 resting on the base, and a non-metallic tube 116 lining the inner face of the electromagnet 115. The valve stem 117 is housed inside the non-metallic tube 116, and this stem is secured to a soft iron armature 118, the latter of which serves as an armature in the magnetic field. The housing 114 is secured in place by a machine screw 119 threading into a lug 120, which in turn is seated on the top of the tube 116; and a spring 121 is inserted between the top of the housing 114 and the electromagnet 115.

The thermostat 44 may comprise a bimetallic strip 122, which makes contact with a contactor member 123 when car heating is required to complete the circuit to the electromagnet 115; and electric current for this circuit is furnished by source of current 124.

The temperature of operation of the thermostat may be varied by moving the contact member 123 relative to the bimetallic strip 122.

It may be desirable to employ a single boiler for a plurality of car heating coils, thereby avoiding the necessity of supplying a separate boiler for each car radiator.

Referring to Fig. 7, the boiler is indicated at 130 and has a steam inlet 131 and an outlet 132, the latter of which may be provided with a steam trap 133 for discharging water from the system. The boiler 130 is equipped with secondary chambers 134, 135, and 136, which receive the volatile liquid when either of the control valves is set for car heating. In this form of the invention, each of the secondary chambers 134, 135, and 136 communicates with a vapor riser 137 connecting a heat radiator 138 to the boiler. The vapor rising from the boiler in the riser 137 passes through the extended pipe 139 into the car radiator 138, and the condensate collecting in the radiator passes through the return line 140 and into the riser 137, assuming that either the thermostatically controlled valve 141 or the manually controlled valve 142 is in its open position, and the safety valve 143 permits passage of the condensate. In the boiler 130, only three secondary chambers are indicated in Fig. 7, but, obviously, more or fewer chambers may be used.

When mounting the boilers directly on the steam line, as shown in Fig. 2, it may be found necessary to provide two or more steam traps throughout the length of the car for removing from the system any condensate which may collect in the steam line.

Referring to Fig. 8, three boilers 28 are shown spaced along the steam train line 32, and a trap 144 is positioned between the second and third boilers. Steam passes through this trap, but any water will drop to the bottom of the trap and be discharged from the system through pipe 145.

In Fig. 2, the return line from the car radiator is shown as extending all the way back to the boiler 28; but, as indicated in Fig. 7, it may be found desirable to tap the return line back into the riser, thus saving considerable piping. Although no specific materials have been specified, it has been found that stainless steel risers and returns are extremely satisfactory, because the low conductivity of this material minimizes heat losses and prevents the heating of portions of the car body where it is not wanted.

Tests have shown that the present heating system is highly efficient and that a very even temperature can be maintained throughout the car without a continuous cycling of the system.

When the closed circulating system for the volatile liquid is first charged, this entire system is first exhausted of air to as high degree of vacuum as possible, and some suitable volatile liquid, such as ethyl alcohol, is inserted. Then the circulating system is sealed.

A small pipe 150 (Fig. 5) extends between riser 60 and return line 67, and serves to vent air from the return line to prevent vapor lock in the system.

The multiple boiler 130, shown in Fig. 7, may be mounted on a branch steam line instead of the

train line. Pipe 131 may terminate at the boiler and not continue as shown at 132 in Fig. 7.

I claim:

1. A modulated heating system including a boiler having a primary and a secondary chamber in heat exchange relationship with each other, a closed circulating system including a secondary chamber, a radiator, a vapor line, and two liquid return lines between the radiator and the secondary chamber, a volatile liquid in the closed system, the radiator being divided so that part of the condensed vapor passes out of the radiator and through one of the liquid return lines, and the remainder passes through the second liquid return line, and a valve in one of said return lines for regulating the flow of condensate back to the boiler.
2. A modulated heating system including a boiler having a primary and a secondary chamber in heat exchange relationship with each other, a closed circulating system including a secondary chamber, a radiator, a vapor line, and two liquid return lines between the radiator and the secondary chamber, a volatile liquid in the closed system, the radiator being divided so that part of the condensed vapor passes out of the radiator and through one of the liquid return lines, and the remainder passes through the second liquid return line, a thermostat responsive to temperatures in the space to be heated, and a valve in one of said return lines responsive to the action of the thermostat for regulating the flow of condensate back to the boiler.
3. A modulated heating system including a boiler having a primary and a secondary chamber in heat exchange relationship with each other, a closed circulating system including a secondary chamber, a radiator, a vapor line, and two liquid return lines between the radiator and the secondary chamber, a volatile liquid in the closed system, the radiator being divided so that part of the condensed vapor passes out of the radiator and through one of the liquid return lines, and the remainder passes through the second liquid return line, a thermostat responsive to temperatures in the space to be heated, a manually controlled valve and a thermostatically controlled valve in one of said return lines for regulating the flow of condensate back to the boiler.
4. A heating system for a railway car comprising a boiler having a primary and a secondary chamber in heat exchange relationship with each other, heating means in the primary chamber, a radiator in the car for supplying heat, a closed circulating system including the secondary chamber of the boiler, the radiator, and a vapor line and liquid return line between the radiator and secondary chamber, a volatile liquid in the circulating system, a thermostat in the car, said liquid line including two lines in parallel, a valve responsive to the operation of the thermostat in one of the parallel lines, and a manually operated, normally closed valve in the other of said parallel lines, both of said valves controlling the circulation of the volatile liquid through the circulating system.
5. A modulated heating system including a boiler having a primary and a secondary chamber in heat exchange relationship with each other, a radiator including horizontally extending spaced headers connected by vertical risers, the lower header being partitioned to form two separate chambers, a closed circulating system including the secondary chamber of the boiler, the radiator, a vapor line from the secondary to the upper riser, a pair of liquid lines, one from each of the chambers in the lower header and emptying into the secondary chamber of the boiler, and a receiver in one of the liquid lines, a volatile liquid in the closed system, and a valve in said last named liquid line for controlling the flow of liquid from the receiver.
6. A modulated heating system including a boiler having a primary and a secondary chamber in heat exchange relationship with each other, a radiator including horizontally extending spaced headers connected by vertical risers, the lower header being partitioned to form two separate chambers, a closed circulating system including the secondary chamber of the boiler, the radiator, a vapor line from the secondary to the upper riser, a pair of liquid lines, one from each of the chambers in the lower header and emptying into the secondary chamber of the boiler, and a receiver in one of the liquid lines, said last named liquid line being divided on the discharge side of the receiver to form two lines in parallel, a volatile liquid in the closed system, a thermostatically controlled valve in one of said parallel lines, and a manually controlled, normally closed valve in the other of said parallel liquid lines, either of said valves being adapted to control the flow of liquor from the receiver.
7. In a railway car having an overhead duct adjacent to the car roof and a steam train line underneath the car, a modulated heating system including a boiler underneath the car having a primary and secondary chamber in heat exchange relationship with each other, means for supplying steam from the train line to the primary chamber, a radiator in the overhead duct including horizontally extending spaced headers connected by vertical risers, the lower header being partitioned to form two separate chambers, a closed circulating system including the secondary chamber of the boiler, the radiator, a vapor line from the secondary chamber to the upper riser, a pair of liquid lines, one from each of the chambers in the lower header and emptying into the secondary chamber of the boiler, and a receiver in one of the liquid lines, a volatile liquid in the closed system, and a valve in said last named liquid line for controlling the flow of liquid from the receiver.
8. A heating system including a boiler having primary and secondary chambers in heat exchange relationship with each other, a radiator in the space to be heated, a closed circulating system including the secondary chamber of the boiler, the radiator, a vapor line from the secondary chamber to the radiator, and a liquid return line from the radiator to the secondary chamber, a volatile liquid in the closed circulating system, a thermostat responsive to temperatures in the space to be heated, a valve in the liquid return line responsive to the thermostat for controlling the liquid flow through the circulating system, a second liquid return line from the radiator to the boiler secondary chamber, and a manually operated valve in the second return line which is normally closed.
9. A heating system including a boiler having primary and secondary chambers in heat exchange relationship with each other, a radiator in the space to be heated, a closed circulating system including the secondary chamber of the boiler, the radiator, a vapor line from the secondary chamber to the radiator, and a liquid return line from the radiator to the secondary chamber, a volatile liquid in the closed circulating system,

a thermostat responsive to the temperatures in the space to be heated, a valve in the liquid return line responsive to the thermostat for controlling the liquid flow through the circulating system, a second liquid return line from the radiator to the boiler secondary chamber, a manually operated valve in the second return line which is normally closed comprising a valve housing, a valve opening in the housing through which liquid passes in its path through the second liquid return line, a movable valve member in the housing adapted to close the valve opening, a permanent magnet around the movable valve member and outside the housing, an armature in the housing in the field of the magnet and secured to the movable valve member, and means manually manipulated from outside the housing for moving the magnet relative to the housing, thereby carrying with it the armature and movable valve member to open and close the valve.

10. In a railway car, a pipe extending lengthwise to the car, a primary heat source in the pipe, a plurality of heating radiators in the car and a secondary heating system including a secondary heating chamber in heat exchange relationship with the primary heat source, a vapor line and a liquid return line extending from each radiator to its respective secondary heating chamber, a volatile liquid in the secondary system, a valve in each liquid line for controlling the flow of condensed liquid in the liquid line, and thermostatic means operatively connected to each valve and responsive to temperature conditions inside the car.

11. In a railway car, a primary heat source, a radiator in the car in the lower region thereof, a duct in the upper region of the car discharging into the car interior, a radiator in the duct, a secondary heating system adapted to supply heat to each radiator including a chamber in heat exchange relationship with the primary heat source and pipes connecting the chamber to each radiator, a volatile liquid in each secondary system, a valve in each secondary system adapted to control the flow of the volatile liquid in said system, a thermostat responsive to temperatures inside the car for controlling the flow for the lower radiator, and a thermostat in the duct for controlling the valve for the duct radiator.

12. In a railway car having thereunder a steam train line extending lengthwise of the car, a heating system for the car including a plurality of secondary chambers spaced lengthwise of the car and surrounding the train line and in heat exchange relationship therewith, a volatile liquid in the chambers, a plurality of radiators in the car, vapor lines and liquid return lines connecting the radiators to the secondary chambers, and a valve in each return line for controlling the flow of liquid therethrough.

13. In a railway car having thereunder a steam train line extending lengthwise of the car, a heating system for the car including a plurality of secondary chambers spaced lengthwise of the car and disposed in heat exchange relationship with the train line, a plurality of radiators in the car, a vapor line and a liquid return line connecting each radiator with one secondary chamber, and a valve in each liquid return line for controlling the flow of liquid in said line.

14. A modulated heating system including a boiler having a primary and a secondary chamber in heat exchange relationship with each other, a closed circulating system including a secondary chamber, a radiator, a vapor line, and two liquid return lines between the radiator and the secondary chamber, a volatile liquid in the closed system, the radiator being divided so that part of the condensed vapor passes out of the radiator and through one of the liquid return lines, and the remainder passes through the second liquid return line, a thermostat responsive to temperatures in the space to be heated, one of the liquid return lines being divided to provide two branch lines in parallel, a manually controlled valve in one branch line, and a thermostatically controlled valve in the other branch line responsive to said thermostat for regulating the flow of condensate back to the boiler.

15. In a railway car, a primary heat source, a plurality of radiators in the car near the floor and arranged throughout the length of the car, a duct in the upper region of the car discharging into the car interior, a radiator in the duct, a secondary heating system adapted to supply heat to each radiator including a plurality of chambers in heat exchange relationship with the primary heat source, closed circulating systems for the secondary heating system including vapor lines and liquid return lines connecting the chambers to the radiators, a volatile liquid in the secondary heating system, valve means in the secondary system adapted to control the flow of the volatile liquid in said system, a thermostat responsive to temperatures inside the car for controlling the flow for the lower radiator, and a thermostat in the duct for controlling the flow for the duct radiator.

16. A heating system including a boiler having a primary source of heat, a plurality of radiators, a plurality of secondary chambers in the boiler in heat exchange relationship with the source of heat, vapor pipes and liquid return pipes connecting the secondary chambers to the radiators to form closed circulating systems, a volatile liquid in the said closed systems, and means for controlling the flow of the volatile liquid through the systems.

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