Dec. 4, 1934. C. A. DUNHAM 1,983,218

HEATING SYSTEM

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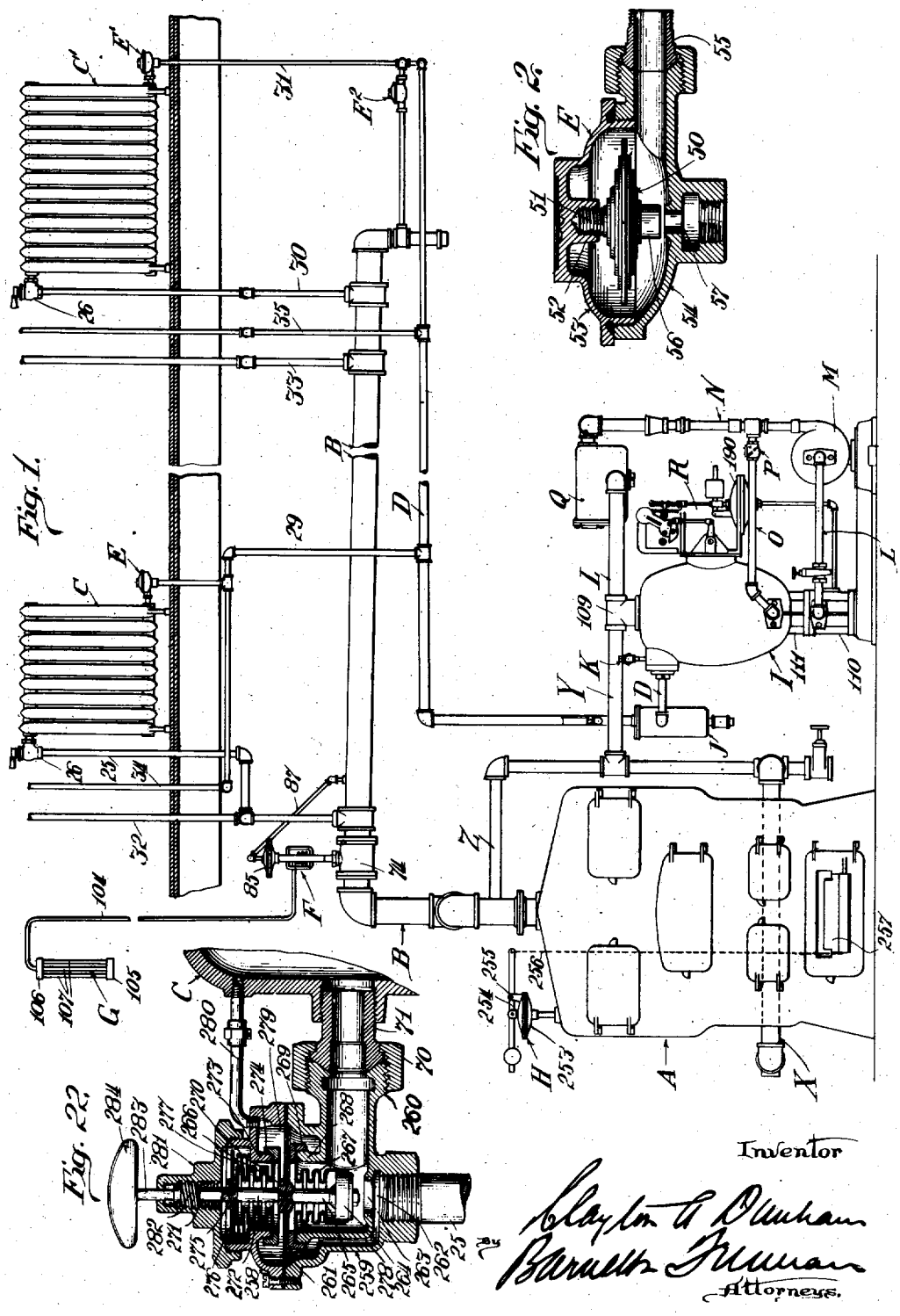


Fig. 1.

Fig. 2.

Fig. 2a.

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HEATING SYSTEM

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Fig. 4.

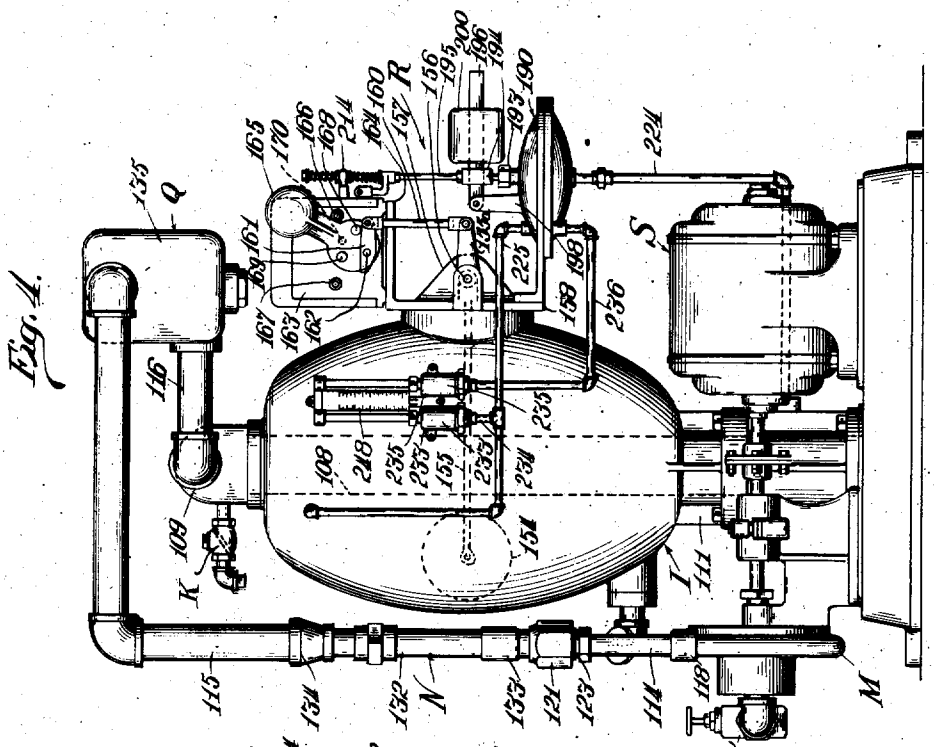
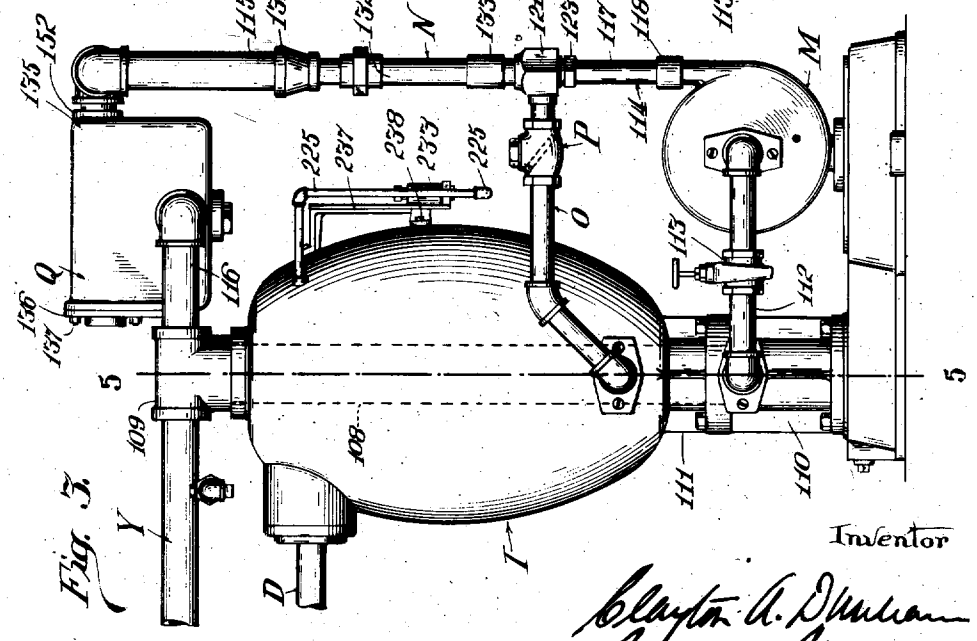


Fig. 3.



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HEATING SYSTEM

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Fig. 5.

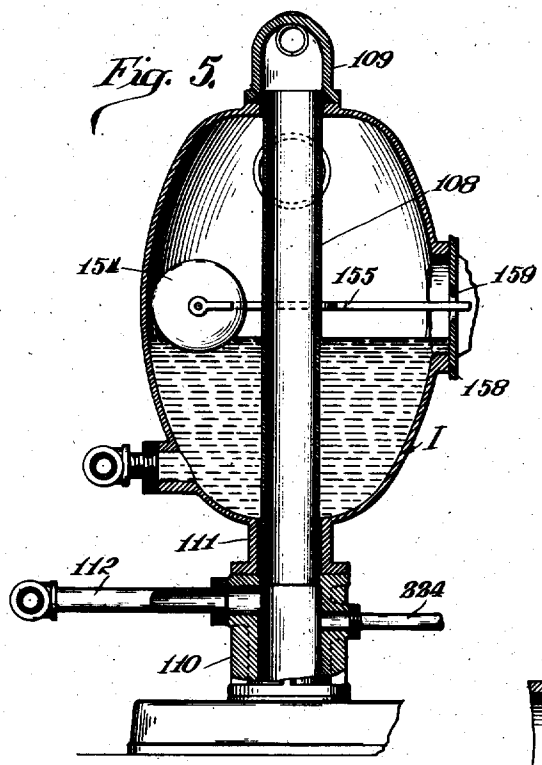


Fig. 6.

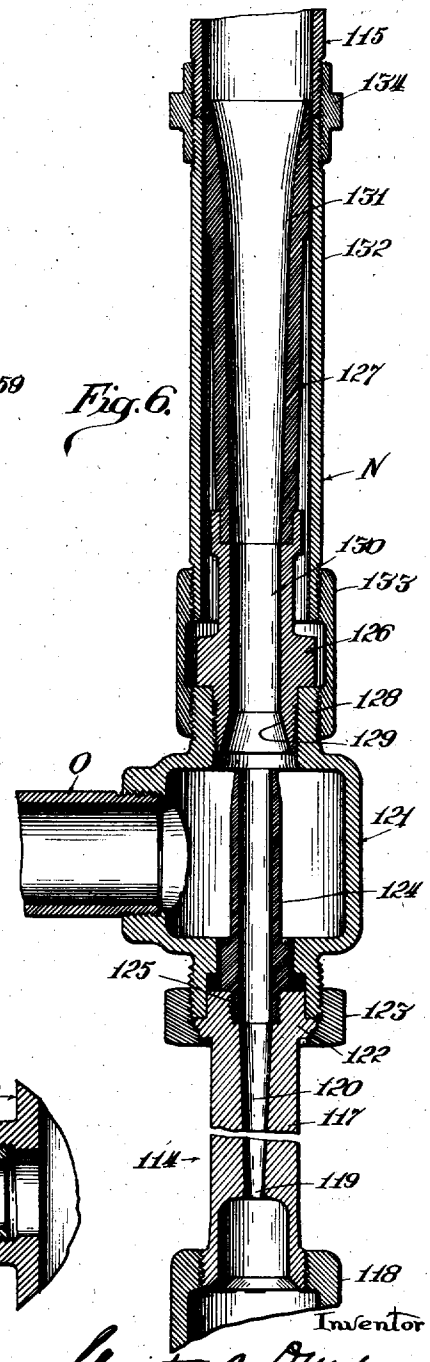
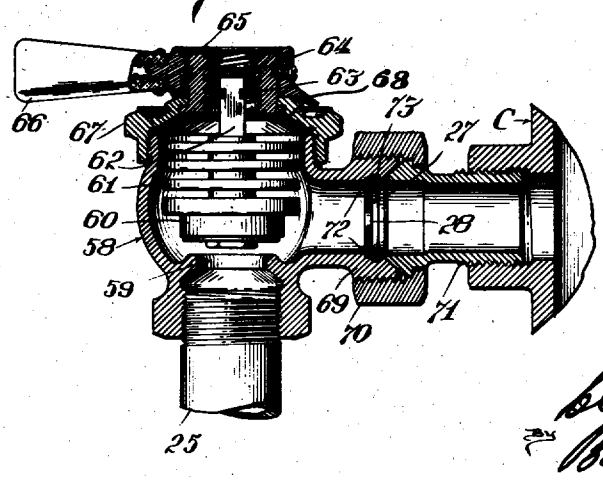


Fig. 7.



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HEATING SYSTEM

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Fig. 8.

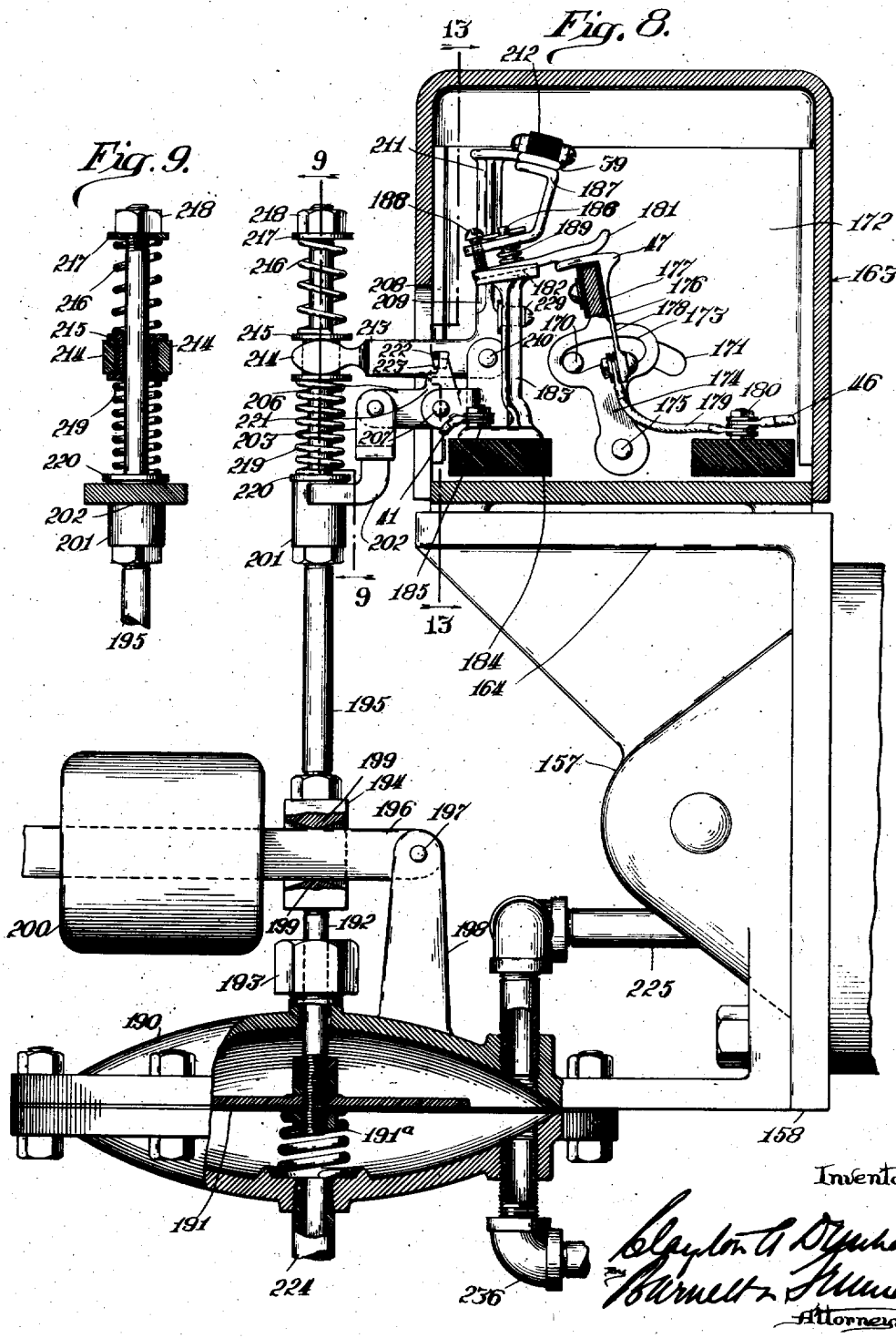


Fig. 9.

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HEATING SYSTEM

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Fig. 10.

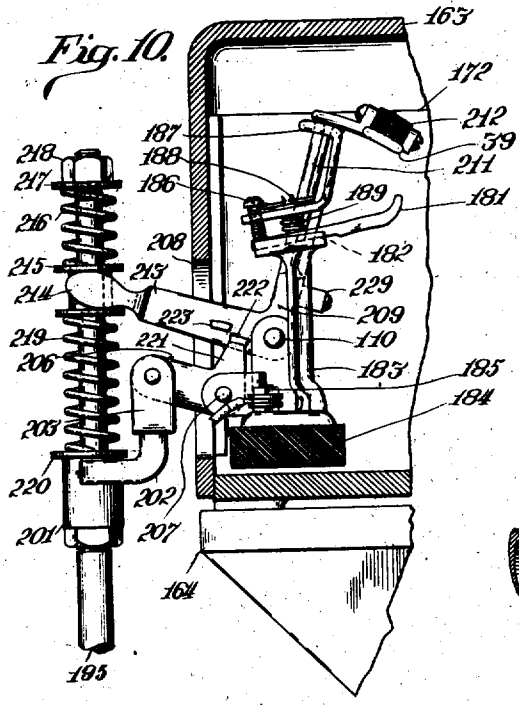


Fig. 12.

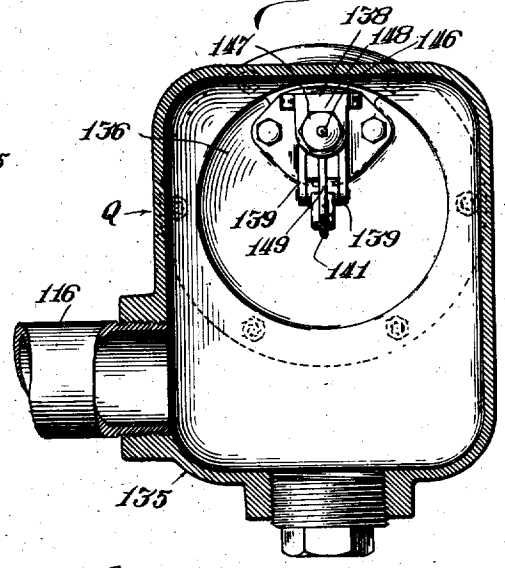
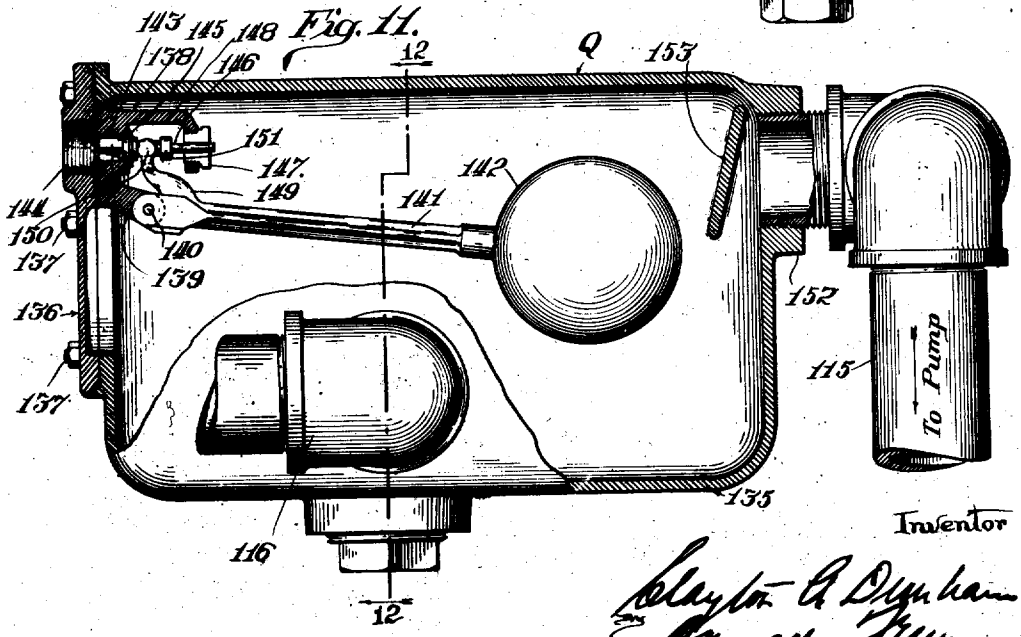


Fig. 11.



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Fig. 14.

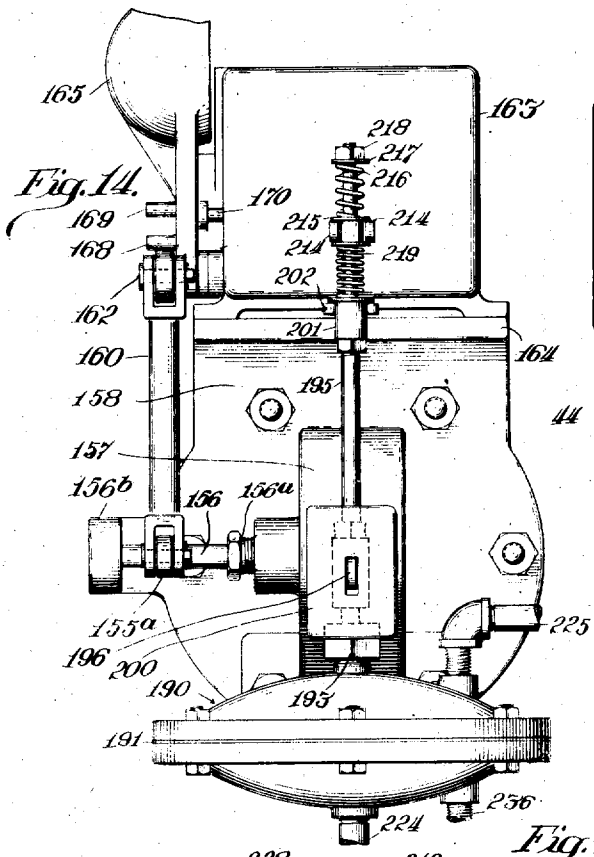


Fig. 15.

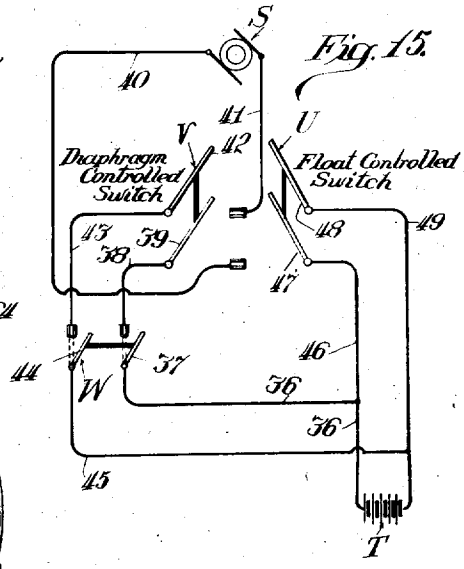
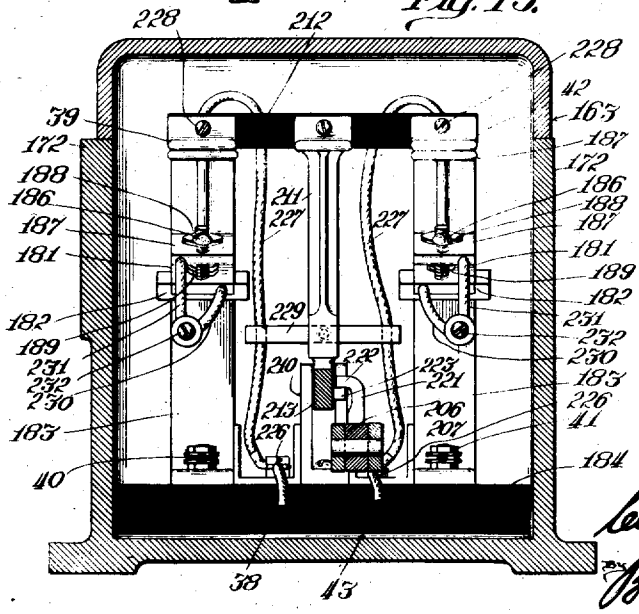


Fig. 13.



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HEATING SYSTEM

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Fig. 16.

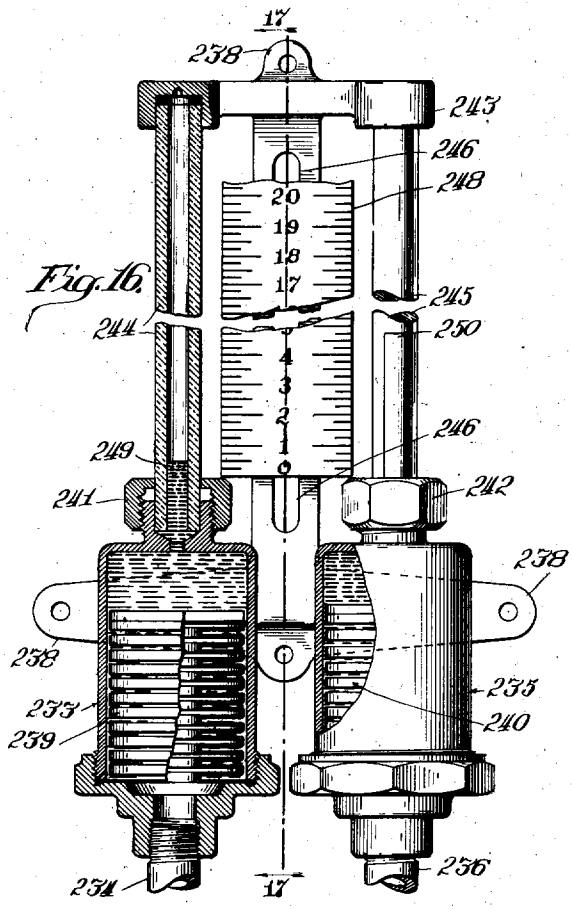


Fig. 17.

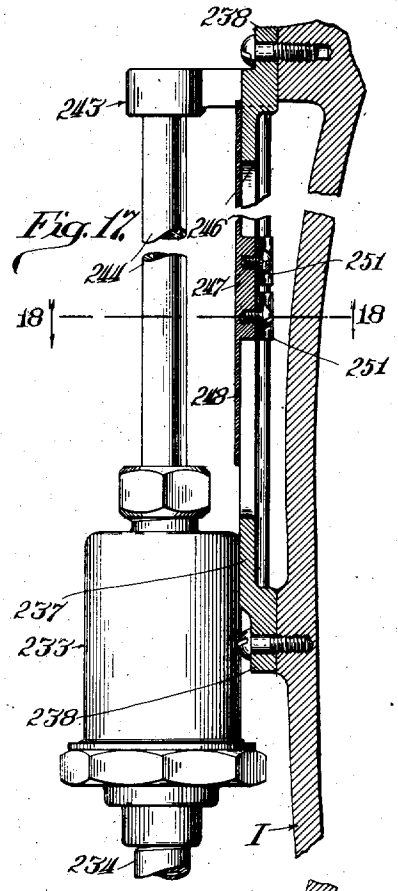


Fig. 19.

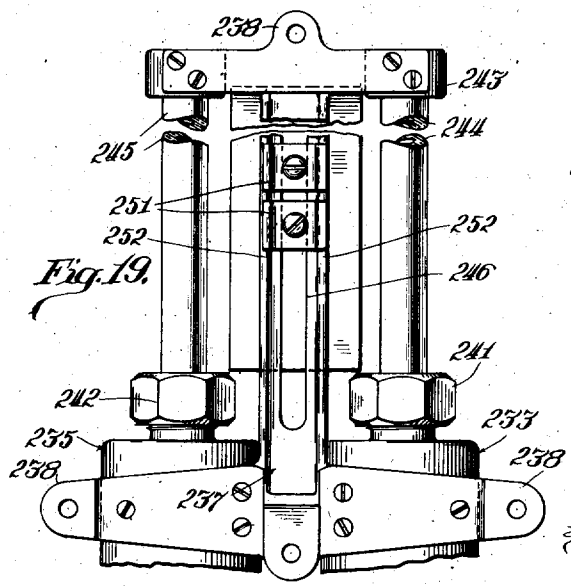
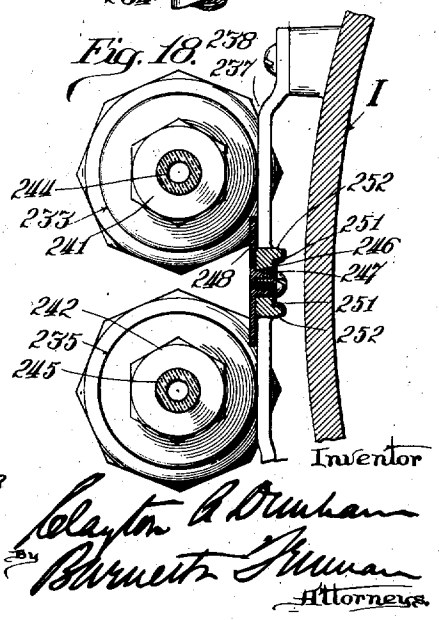


Fig. 18.



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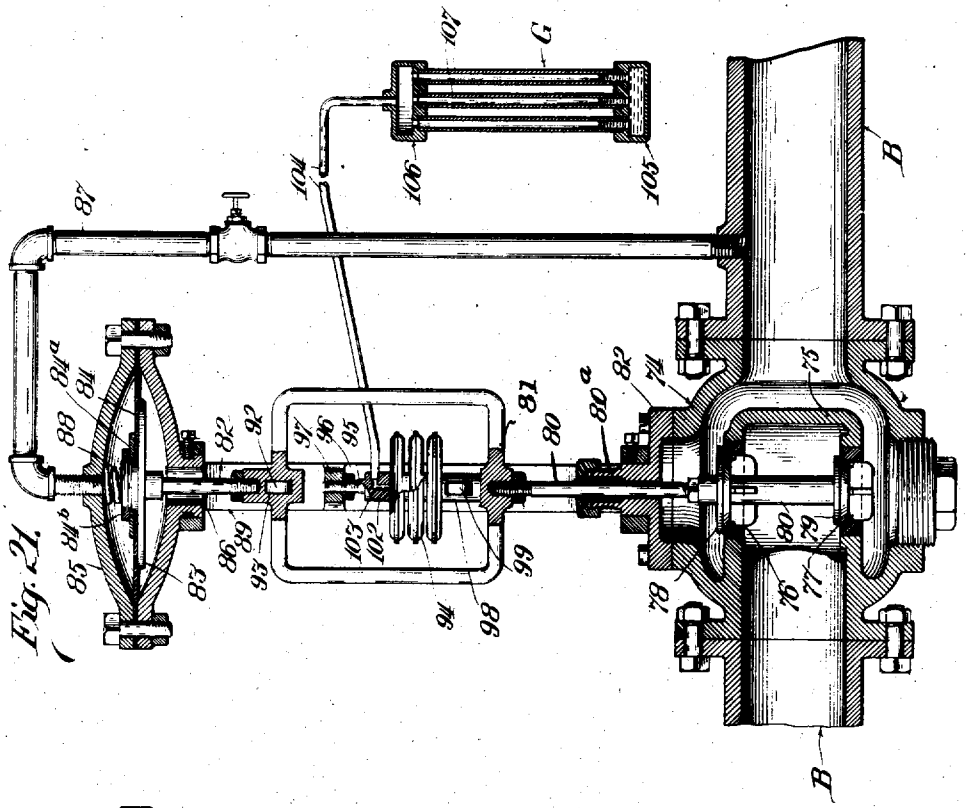


Fig. 21.

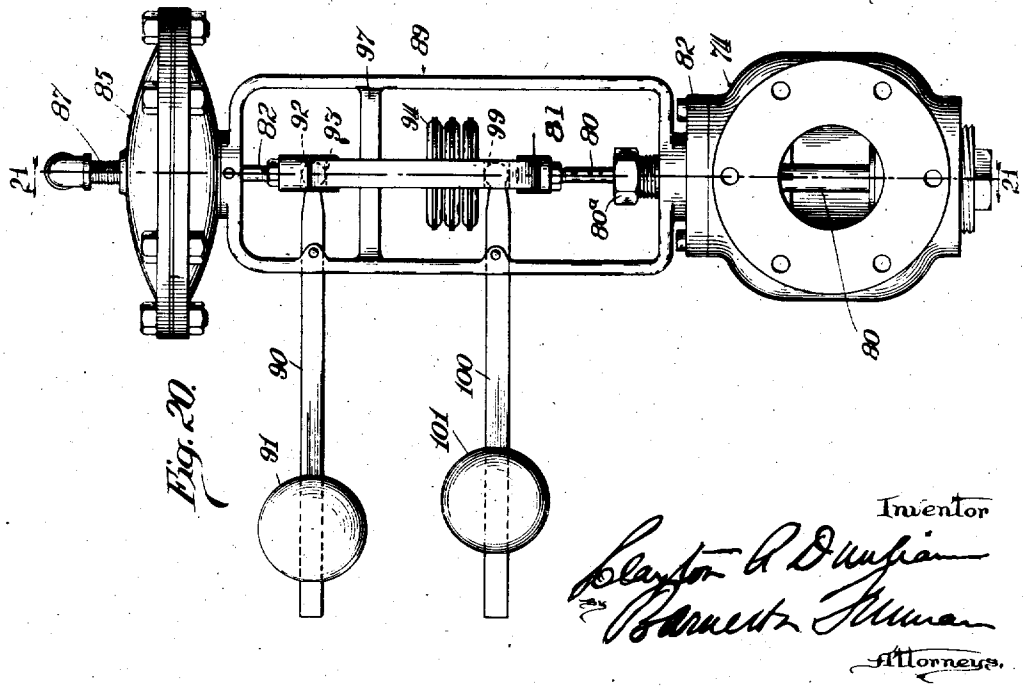


Fig. 20.

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Patented Dec. 4, 1934 1,983,218

UNITED STATES PATENT OFFICE

1,983,218

HEATING SYSTEM

Clayton A. Dunham, Glencoe, Ill., assignor to C. A. Dunham Company, Marshalltown, Iowa, a corporation of Iowa

Application October 18, 1923, Serial No. 669,363

47 Claims. (Cl. 237—9)

My invention relates to steam heating apparatus and its general purpose is to make certain improvements in this art conducive to more economical operation, more uniform distribution of the steam to the places more or less remote from the source of supply where the steam is condensed, better and more accurate automatic control of the apparatus for generating and distributing the steam, together with a wider range of adjustability for varying conditions of temperature than is possible with the steam heating systems heretofore devised, and to accomplish these results by certain devices and mechanisms which are simple and inexpensive in their construction, positive and reliable in operation, and which may be readily adapted for use, if need be, in connection with existing installations.

More specifically, the objects of the invention comprise the provision of a heating apparatus with certain new and improved constructions, devices and expedients, preferably used in combination as shown in the drawings but susceptible of employment singly in some cases as will appear hereinafter, whereby a constant but adjustable, that is a controlled, difference in pressure may be maintained between the supply and return piping of the apparatus; whereby the condensate and air may be withdrawn from the radiators and the condensate returned to the boiler, either continuously or intermittently as a certain volume of water is accumulated; whereby a pumping means will be operated under boiler pressure; whereby the quantities of steam received by the several radiators will be proportioned to their requirements regardless of the positions of the radiators with relation to the source of supply; whereby the system will be capable of variable operation so that the pressure in the radiators may be kept either at or above or below atmospheric pressure; and whereby the maximum quantity of steam that may be introduced into the several radiators or heating units is subject to centralized control independent of conditions existing in the localities of the several radiators.

The invention consists in the new and improved constructions, arrangements and devices to be hereinafter described and claimed for carrying out the above stated objects and such other incidental objects as will be adverted to in the following description of the preferred embodiment of the invention shown in the accompanying drawings.

In the drawings:

Fig. 1 is a diagrammatic representation of the heating system containing the improvements of my invention.

Fig. 2 is a sectional view of one of the radiator steam traps.

Fig. 3 is a side elevation of the mechanism for withdrawing water and air from the return pipe of the radiating system.

Fig. 4 is a view, in elevation, of the same apparatus viewed from a plane at right angles to the plane of Fig. 3.

Fig. 5 is a sectional view on line 5—5 of Fig. 3.

Fig. 6 is a longitudinal sectional view of the jet exhauster forming part of the apparatus shown in Figs. 3 and 4.

Fig. 7 is a sectional view of the inlet pipe of one of the radiators and the valve associated therewith.

Fig. 8 is a sectional elevation illustrating the differential controller for maintaining constant difference of the pressure between the supply and return mains of the radiating system.

Fig. 9 is a sectional view on line 9—9 of Fig. 8.

Fig. 10 is a fragmentary view of the upper portion of the mechanism shown in Fig. 8 but with the parts in a different position.

Fig. 11 is a longitudinal sectional view of the device for venting the hurling water circuit of air.

Fig. 12 is a sectional view taken on line 12—12 of Fig. 11.

Fig. 13 is a sectional view taken on line 13—13 of Fig. 8.

Fig. 14 is a fragmentary side elevation of the controlling mechanism shown in Figs. 8, 9, 10 and 13.

Fig. 15 is a wiring diagram of the controller.

Fig. 16 is a fragmentary view, in elevation with parts in section, of a differential gauge by means of which a reading of the differences of pressure between the supply and return mains may be obtained.

Fig. 17 is a sectional view on line 17—17 of Fig. 16.

Fig. 18 is a sectional plan on line 18—18 of Fig. 17.

Fig. 19 is a fragmentary view, in elevation, of the gauge viewed from the back.

Fig. 20 is a view, in elevation, of a pressure reducer arranged in the steam supply main.

Fig. 21 is a sectional view on line 21—21 of Fig. 20; and

Fig. 22 is a sectional view illustrating a modified form of radiator inlet valve.

Referring first to Fig. 1, A designates a steam generator, B a steam supply pipe leading from the boiler of the generator for supplying steam to the

radiating system consisting of a plurality of radiators, two of which are shown and designated C and C', respectively. D is a common return pipe and E, E', E² are steam traps associated with the radiators C and C' and with the end of the supply main B. F is a pressure reducer or pressure regulator in the supply pipe B controlled by pressure of the steam on the low pressure side of the reducer and by a thermostat G which may be located at any desired point either within or outside of the building heated by the apparatus. H is a device subject to pressure in the boiler of the generator for controlling the operation of the generator through the closing and opening of one or more of the dampers. I is a water tank at the end of the return pipe D and J a strainer arranged in the return pipe in advance of the water tank I. The latter is provided with an outwardly opening check valve K. L is a hurling water pipe circuit one leg of which extends through without communicating with the water tank I. In the circuit L is arranged a centrifugal pump M and a jet exhauster N which latter draws water from the tank I into the hurling circuit through a pipe O having a check valve P opening in the direction of the exhauster. The hurling circuit also contains a trap or device Q for ridding the hurling water of air drawn into the same from the radiating system. The term "air" is intended to include any incondensable gas and is used in this sense in the appended claims. R is a controlling device for governing the motor S (Fig. 15) which operates the pump M. The controller has a dual function. It operates to start and stop the motor responsive to pressure fluctuations in the supply and return pipes B and D so as to maintain a constant but adjustable pressure differential as between the medium in these pipes. It also starts and stops the pump in accordance with changes in the water level in the tank I. Any suitable pumping mechanism might be employed in place of that shown.

Referring to Fig. 15, T is a source of supply of current for the pump motor S. U is a circuit breaker operated through controlling mechanism R by a float in tank I, V a circuit breaker operated through controller R in accordance with changes in the pressure differential in the supply and return mains, and W a hand operated switch for putting the differential control out of operation.

Again referring to Fig. 1, X designates the feed pipe of the boiler which is connected with the hurling circuit by a pipe Y and with the supply pipe B by a pipe Z.

Before describing in detail the construction of the several instrumentalities enumerated above, a brief summary will be given of the operation of the system as a whole. In comparing the detail views of the apparatus shown in Figs. 3 and 4 with the general view of Fig. 1, it will be observed that for the purpose of general illustration of the whole apparatus the controller R has been arranged in Fig. 1 to the right of tank I instead of back of it, as shown in Figs. 3 and 4.

Steam from the generator passes into the supply main B and after passing the pressure reducer F enters radiator C through pipe 25 and hand operated valve 26. Interposed between valve 26 and the radiator is a restricted inlet opening in the form of an orifice plate 27 (Fig. 7) which restricts the inflow of steam so that under normal conditions of operation the maximum quantity of steam that the radiator will receive is fixed and proportioned to the condensing capacity of the radiator. The orifices 28 of the plates 27 of the various radiators of the system will differ in size dependent upon the relative positions of the several radiators to the source of supply of steam so that all of the radiators regardless of their position, receive substantially the same maximum quantity of steam (assuming radiators of equal volumetric contents), which quantity may, of course, be reduced by operation of the hand operated valves 26. The steam is retained in the radiator C by steam trap E which, however, permits outflow of water of condensation and air through pipe 29 to the common return pipe D.

30 designates the feed pipe for radiator C' and 31 the outlet pipe leading to the common return pipe D. 32 and 33 indicate feed pipes extending to other radiators, not shown, and 34, 35 the outlet pipes from these other radiators.

The pressure reducer F operates to throttle flow of steam through the supply pipe B in case of a rise of pressure in the boiler so that the pressure on the radiator side of the pressure reducer cannot exceed a certain maximum for which the pressure reducer is set. The pressure reducer is also controlled by thermostat G so that if the temperature in the locality of the thermostat rises above a certain point, the steam supply to the radiators is throttled regardless of the pressure on the low pressure side of the pressure reducer F.

Water of condensation and air withdrawn from the radiating system passes through pipe D and strainer J into tank I which is vented through check valve K to prevent accumulation of pressure, the check valve opening outwardly so as to be closed by a vacuum produced in the tank. The hurling circuit L contains water and when pump M is in operation this water is forced continuously through the circuit and through the jet exhauster N which produces a suction on pipe O that draws fluids from the tank I into the hurling circuit. Air in the hurling circuit is discharged through the venting device Q which is constructed so as to prevent the outflow of water. The excess of water drawn into the hurling circuit is forced from the same through pipe Y into pipe X and thence into the boiler or generator A. Through pipe Z the pump and hurling water circuit are under boiler pressure. Pipe Y is located preferably at substantially the normal water level of the boiler.

The pump, therefore, serves two functions: It creates a vacuum in the return pipe of the radiating system which operates to withdraw from the radiating system the condensate and air therein; and it forces the condensate back into the boiler so as to maintain the water therein at a relatively constant level.

The pump is subject normally to a dual control. Assuming that switch W is closed any change in pressure either in the supply main or in the return main which results in an increase in the difference in pressure in said pipes will operate the controller R to stop the pump and thereby bring about a decrease of the suction on the return pipe until the proper balance is restored.

Referring to Fig. 15, with switch W closed by hand and switch V closed through balancing of pressures on the pressure responsive element or controller R, current will flow through the motor over the following circuit: Source of current supply T, wire 36, switch member 37, wire 38, switch member 39, wire 40, pump motor S, wire 41, switch member 42, wire 43, switch member 44 and wire 45 to the source of current supply.

By opening the switch W the differential con-

trol may be put out of operation but whether the differential control is operative or not the pump motor will be set in operation when the water in tank I rises to a certain level so that the accumulated condensate is always taken care of. With switch W closed the pump will be in operation either when necessary to maintain proper difference in pressure between the supply and return mains or when water has accumulated in tank I. With the float controlled switch U closed the pump motor is supplied over the following circuit: battery T, wire 36, wire 46, switch member 47, wire 40, pump motor S, wire 41, switch member 48 and wire 49 to the battery.

The apparatus, the parts of which have been enumerated above and their general relationship explained, will now be described in detail.

Steam traps of any suitable construction may be used at the outlets of the radiators. A preferred form of trap is shown in Fig. 2. 50 designates a corrugated vessel containing an expansible fluid, the vessel being provided with a stud 51 which is screwed into a boss 52 in the upper section 53 of a casing 54 having nipple 55 for attachment to the radiator. The thermostatic vessel 50 is provided on its under side with a valve 56 adapted to seat over a port 57 which leads to the radiator outlet pipe 29.

The radiator valve is shown in Fig. 7 and is preferably constructed as follows: 58 is a valve casing having an inlet port 59 communicating with feed pipe 25 adapted to be closed by a valve 60 arranged on a corrugated structure 61, having a stem 62 provided on opposite sides with notches 63 for non-rotatable engagement with a nut 64 which has a threaded engagement with an internal threaded sleeve 65 adapted to be rotated by a handle 66, the sleeve and handle being supported on the bonnet 67 of the valve casing. The stem 62 is non-circular in cross section and extends through an opening of similar shape in a guide plate 68 which is interposed between the upper edge of the casing and the bonnet. Consequently when the handle 66 is turned nut 64 is forced downwardly so as to seat the valve 60 over port 59. The outlet port of the valve casing is through a boss 69 secured by union 70 to a nipple 71 which is screwed into the radiator C. The orifice plate 27 above referred to is arranged in the boss 69 and is held against a shoulder 72 by a split ring 73. The orifice plate is removable so that the valve for each of the radiators may be fitted with a plate having an orifice of the proper size to provide for the admission of the proper amount of steam to the radiator dependent upon the position of the radiator with respect to the source of supply of the other radiators of the system.

The pressure reducer F arranged on the supply pipe B is preferably constructed as follows (Figs. 20 and 21): 74 is a valve casing interposed between sections of pipe B. The casing has an interior web 75 provided with two ports 76, 77 which are adapted to be closed by a pair of valves 78, 79 on a stem 80 which passes through a stuffing box 80^a in the bonnet 82 of the valve casing. Valve stem 80 is secured to a yoke 81 and the upper end of the yoke to a stem 82 on a plate 83 fastened to the under side of a flexible diaphragm 84 arranged in the diaphragm casing 85. The space under the diaphragm 84 is open to the atmosphere through an opening 86 in the bottom of casing 85. The space above the diaphragm 84 is connected by a pipe 87 with supply pipe B on the low pressure side of the pressure reducer. 88 is a spring interposed between the upper section of the diaphragm casing 85 and a follower plate 84^a secured to the diaphragm 84 by lock nut 84^b. The diaphragm casing 85 is supported on a yoke structure 89 to which is pivoted an arm 90 carrying an adjustable weight 91, the inner end of the arm being provided with a circular projection 92 which enters a slot 93 in the upper end of yoke 81. Weight 91 is set to determine the pressure which it is desired to maintain on the low pressure side, that is, the radiator side, of the pressure reducer. If the pressure on this side of the device exceeds that which is intended to be maintained, diaphragm 84 is deflected downwardly, against the action of the weight, moving valves 78, 79 against or toward their seats so as to shut off or diminish the inflow of steam through ports 76, 77 until the balance shall have been restored.

The temperature controlled regulator comprises a motor means in the form of a flexible, corrugated vessel 94 which is secured by means of an upstanding threaded stem 95 and lock nut 96 to a cross piece 97 on the yoke structure 89. The expansible vessel is provided on its under side with a boss 98 slotted to receive a circular projection 99 on the end of a lever 100 pivoted to the yoke structure 89 and carrying an adjustable weight 101. The weight, therefore, tends to compress the vessel 94. Interposed between the threaded stem 95 and the flexible portion of the vessel is a boss 102 formed with a port 103 leading to the interior of the vessel, which port is connected by a tube 104 with the thermostat G which, as shown, consists of lower and upper headers 105, 106 connected by tubes 107. Thermostat G contains a fluid which expands and contracts with fluctuations in temperature. On rise of temperature to the point at which the thermostat is designed to act, the pressure of the fluid in the thermostat G, pipe 104 and expansible vessel 94 overcomes the force exerted by weight 101, (which force will, of course, depend upon the position to which the weight has been adjusted on lever 100) and moves the valves 78, 79 against or toward their seats to shut off or throttle flow of steam to the supply main B. The arrangement is such, it will be observed, that even though the presure on the radiator side of the pressure reducer is insufficient to deflect diaphragm 84 to close or throttle the ports of the pressure reducer, if the temperature is reached at which thermostat G is set to operate, the thermostat will, nevertheless, bring about the closing or throttling of the ports.

The apparatus for exhausting the return main D of the radiating system and introducing the condensate as feed water into the boiler of generator A is preferably constructed as follows: The hurling water circuit L (Figs. 3, 4, 5 and 6) is composed of a pipe 108 extending from top to bottom through the water tank I, a T 109 on the top of the tank, a hollow fitting 110 which supports the tank (the latter having a flanged neck 111 which rests upon the fitting 110), a pipe section 112, preferably provided with a shut-off valve 113, constituting the induction pipe of the centrifugal pump M, a pipe section 114 leading to the jet exhauster N (Fig. 6), a pipe section 115 leading from the jet exhauster to the vent trap Q, and a pipe section 116 connecting the vent trap with the T 109. With the pump M in operation water is driven continuously through the hurling circuit as above described.

Water is drawn into the hurling circuit from

tank I through pipe O and check valve P by means of the jet exhauster N (Fig. 6) which is preferably constructed as follows: The jet nozzle of the exhauster comprises a member 117 secured by union 118 to the eduction pipe 114 of pump M and formed with a contracted throat at 119 and with a diverging passageway 120. A casing 121 is secured to the enlarged end 122 of jet member 117 by means of a union 123, pipe O being tapped into the side of this casing. Projecting through the casing is a nozzle member 124 having a threaded end 125 screwed into the end of nozzle member 117. The bore of nozzle member 124 is preferably of uniform diameter. The receiving tube of the jet exhauster is composed of two members 126, 127 having a tight fit one with the other, member 126 having a threaded connection with a boss 128 on casing 121. The throat of member 126 is flared as indicated at 129, the main portion of the bore 130 being of uniform diameter. The passageway 131 through member 127 is of gradually increasing cross sectional area as is common with jet exhausters. 132 is an enclosing pipe section secured to boss 128 by union 133 and to pipe section 115 by union 134. The water of the hurling circuit will ordinarily be quite hot and as a result, if a jet exhauster of ordinary construction were used diminution in kinetic energy of the jet would result from the tendency of the warm water to expand in throat 129. That is, with warm water and an ordinary nozzle in use instead of the one shown there would be less contraction of the jet issuing from nozzle member 124 than with cold water. By the construction shown the expansion is controlled in member 117 so that the heat released as a result of the pressure change within the nozzle is utilized to increase the kinetic energy of the water particles as a result of the expansive action and when the water issues from the straight portion of the nozzle, that is member 124, it comes in a coherent stream which passes across the suction space in casing 121 and enters the flared portion of member 126 as a homogeneous jet.

The venting trap Q for ridding the water of the hurling circuit of entrained air is preferably constructed as follows (Figs. 11 and 12): 135 is a casing provided at one end with a separately formed closure plate 136 secured to the body of the casing by bolts 137. Secured to the inside of the cover plate is a casting 138 provided with a forked bracket 139 to which is pivoted at 140 the arm 141 of a float 142. Casting 138 is formed with a port 143 in alignment with an opening 144 in the cover plate in which port is arranged a valve 145 having a stem 146 passing through a bushing 147 supported by a web 148 on casting 138. The float arm 141 has a finger 149 with a forked projection 150 straddling the valve stem 146 and bearing upon the valve 145 on one side and a collar 151 on the other. An accumulation of water in casing 135 will cause float 142 to close the port 143, thereby preventing the outflow of water through the vent. Under ordinary conditions the water level in casing 135 will be held low enough by the air trapped in the upper portion of tank Q so that valve 145 is unseated at intervals to permit the escape of some of this air. Pipe section 115, as above stated, leads to the casing of the trap, being shown as tapped into a boss 152 on one end of the casing. Preferably the casing is formed with an interior baffle web 153 arranged in front of the water inlet. Pipe 116 leads from the lower part of the casing to the T 109.

Excess of water in the hurling circuit is forced from the T 109 through pipes Y and X into the boiler below the normal water level therein. The hurling circuit operates under boiler pressure which is balanced on opposite sides of pump M so that fluctuations in the pressure of steam in the boiler do not affect the operation of the pump. Moreover, the boiler pressure does not tend to back up the water in the vent trap Q.

The motor which intermittently drives pump M is controlled through changes in the level of the water accumulated in tank I by the float controlled mechanism preferably constructed as follows (Figs. 4, 5, 8, 13 and 14): 154 is a float in the tank I arranged on an arm 155 which is secured to a shaft 156 within the tank extension 157 on a plate 158 secured to the side of the tank I, the lever passing through an opening 159 in the plate 158. The shaft 156 is journaled in a stuffing box 156^a in the wall of tank extension 157 and in a bracket arm 156^b on plate 158. A crank arm 155^a on the outer portion of shaft 156 is connected by a link 160 with a trip 161 which latter is pivoted at 162 to the side of a casing 163 which is supported on a shelf 164 projecting outwardly from plate 158. On pivot stud 162 is mounted a weight 165 adapted to be moved back and forth between stops 166, 167. The weight is provided with a pair of studs 168, 169 adapted to be engaged by the trip 161. The weight 165 is provided with a stud 170 which projects through a slot 171 in the side wall 172 of casing 163 (Fig. 8) and through a slot 173 in a rocking member 174 which is pivoted at 175 to the side wall 172 of the casing. The rocking member 174 is provided with a cross bar 176 on which is arranged, with the interposition of suitable insulation 177, a pair of contact shoes 47, 48 (diagrammatically shown in Fig. 15). The contact shoes 47, 48 are provided with extensions 178 connected by conductors 179 to binding posts 180. The line wires 46, 49 (Fig. 15) are connected with the binding posts 180. The shoes 47, 48 are adapted to bear against a pair of contacts 181 supported on inclined ledges 182 on the upper ends of standards 183 mounted on an insulating block 184 in the casing. On the standards 183 are binding posts 185 to which are connected the pump motor leads 40 and 41. The contacts 181 are held in place on the standards by means of guide studs 186 fixed to the ledges 182 and extending loosely through the contacts and through an upper pair of contacts 187 (for the differential control) and by set screws 188 extending through the upper and lower contacts and into the ledges 182, coiled springs 189 being interposed between the upper and lower contacts of each pair. With this arrangement a yielding pressure is exerted between the contact shoes 47, 48 and contacts 181, and also between the coacting pairs of contacts for the differential control to be hereinafter described.

Operation of the float control.—When the level of the water in tank I falls, the float lever 155 is rocked raising link 160 and bringing trip 161 against stud 168 on the tilting weight 165. The weight is thus swung from right to left (Fig. 4) until it passes center, whereupon it falls to the left until stopped by the bumper or stop member 167. This falling movement of the weight brings stud 170 (Fig. 8) against the right hand end of slot 173 in the rocking switch member 174 rocking the switch member to the right so as to sep-

arate contact shoes 47, 48 from the cooperating pair of contact 181 by a quick snap movement. With the contact shoes 47, 48 bearing against the contacts 181 the pump leads 40, 41 are connected with the line wires 46, 49 as indicated by the diagram (Fig. 15). When this circuit is broken as above described, the pump motor is stopped unless it is receiving current over the circuit controlled by the pressure differential controlled mechanism which will be described next.

The differential control mechanism for controlling the pump motor S so as to maintain a constant, though adjustable difference of pressure as between the supply and return mains of the radiating system is preferably constructed as follows (Figs. 4, 8, 9, 10, 13 and 14): 190 is a diaphragm casing supported on the bracket plate 158 on the side of tank I (Fig. 4). The casing contains a flexible diaphragm 191 under which is arranged a spring 191ª to which is secured a rod 192 (Fig. 8) extending through a stuffing box 193 and attached to a yoke 194, the upper end of which carries a rod 195. A lever 196 is pivoted at 197 to a standard 198 on the diaphragm casing and extends through yoke 194 having a knife edge bearing 199 on which the lever fulcrums. The lever 196 carries a weight 200. Fixed to rod 195 is a collar 201 having a curved arm 202 provided with a forked end 203 connected to a bell crank 206 pivoted at 207 to the casing 163, the bell crank extending into the casing through a slot 208 in the side thereof. A second bell crank 209 is pivoted to a bracket 210 in the casing and to the upper end of the upstanding arm 211 of this bell crank is secured a cross bar 212 carrying contact shoes 39, 42 (diagrammatically shown in Fig. 15) which are adapted to bear against the pair of contacts 187 previously described. The other arm 213 of the bell crank projects out through the slot 208 in the side wall of the casing and has a forked portion 214 with rounded edges engaging a collar 215 slidably arranged on rod 195 between a coiled spring 216 held against a washer 217 positioned by nut 218 on the upper end of the rod, and a longer coiled spring 219 bearing against a washer 220 positioned against the fixed collar 201. The upstanding arm 221 of bell crank 206 has a hook 222 which is adapted to extend over a lug 223 on the arm 213 of bell crank 209. The lower compartment of the diaphragm casing 190 is connected by a pipe 224 with the pressure side of the system at some convenient point, the pipe being shown as extending into the fitting 110 which forms part of the hurling circuit. The upper compartment of the diaphragm casing 190 is connected with the vacuum side of the apparatus by a pipe 225 which is shown as tapped into the tank I.

Line wires 38, 43 are connected with binding posts 226. (Fig. 13.) From these binding posts extend a pair of wires 227 to the binding posts 228 on the contact shoes 39, 42, wires 227 being guided by a cross member 229 on the bell crank 211. In order to insure proper electrical connection between the standards 183 and the contacts 181 and 187 wires 230 and 231 are provided which extend to these contacts respectively, from binding posts 232 on the standards.

Operation of the differential control.—The differential control is put into or out of operative connection with the apparatus by closing or opening hand operated switch W (Fig. 15). So long as the difference in pressure between the supply and return mains is less than that which the apparatus is intended to maintain the contact shoes 39, 42 bear upon contact members 187 so that the pump motor is supplied with current through line wires 36, 38 and 43, 45, and motor leads 40, 41. With switch W closed the system is subject to the differential control regardless of whether the float controlled switch U is opened or closed. If the balance of pressures on diaphragm 191 is disturbed either by increase of pressure under the diaphragm or by diminution of pressure above the same to increase the pressure differential over that for which the controller is set, the diaphragm is deflected upwardly against the action of weight 200, the position of which on lever arm 196 determines the pressure differential sought to be maintained. The upward movement of rod 195 rocks the bell crank 206 but without disturbing the position of bell crank 209 so long as the hook 222 bears upon the lug 223 on bell crank 209. During this initial upward movement of rod 195 spring 219 is compressed. The spring 219 is in fact compressed to a certain extent when the parts are in the intermediate position shown in Fig. 8. As soon as the upward movement of the rod releases the hook 222 from the lug 223 bell crank 209 is given a sudden rocking movement by the force of spring 219 which moves the contact shoes 39, 42 away from contacts 187 with a snap action preventing arcing. The spring 219 which is compressed more than spring 216 gives sleeve 215 a movement of greater amplitude than the vertical movement of rod 195 to effect a sufficiently wide separation of the contacts as shown in Fig. 10. The pump motor circuit governed by the differential controlling mechanism is now broken and the motor stopped, unless there is an excess of water in tank I, in which case the pump will continue to operate because of the closed position of the float controlled switch U. Fig. 15 shows the position of the differential controller in the circuit breaking position of its parts.

When the balance of pressures on diaphragm 191 is restored rod 195 is moved back to its normal position. During the first part of this movement hook 222 passes under lug 223 keeping the contacts in their separated positions and compressing spring 216. When the hook clears the lug bell crank 209 is given a quick movement through action of spring 216 which moves the contact shoes 39, 42 against contacts 187 closing the circuit. The pump M and exhauster N are designed so as to be capable of withdrawing from the radiating system a larger quantity of condensate than will be formed under any normal conditions. Therefore if the difference in pressure between the supply and return mains becomes less than the intended differential, resulting in a downward deflection of diaphragm 191 the pump will continue its operation for a proportionately longer period of time, namely until the diaphragm has been deflected past center and to its upper or circuit breaking position.

The apparatus is preferably provided with a gauge by which the difference in pressure between the supply and return portions of the system may be ascertained. In the preferred arrangement shown (Figs. 4 and 16 to 19 inclusive) the gauge is connected with the pressure side of the differential control diaphragm casing 190 and with the pipe which connects the vacuum side of the differential casing with tank I.

The differential gauge is preferably constructed as follows: 233 is a casing connected by pipe 234 with pipe 225. 235 is a casing connected

by pipe 236 with the lower side of the diaphragm casing 190. These casings are supported on a plate 237 having ears 238 for attachment to the side of tank I. Within the casings are a pair of corrugated membranous flexible structures 239, 240 open at the bottom to pipes 234 and 236. Supported in stuffing boxes 241, 242 on the tops of the casings and in recesses in the cross member 243 on the plate 237 are a pair of glass gauge tubes 244, 245. The casings are filled with bodies of liquid which rise to a greater or less extent in the gauge tubes. The base plate 237 is formed with a groove 246 to receive a sliding member 247 on which is fastened a scale plate 248 provided with graduations indicating pressure units, ounces of pressure, for example, and fractions thereof, beginning at zero at the bottom of the plate. The liquid column 249 in gauge glass 244 will rise to a level determined by the pressure on the vacuum side of the apparatus while the liquid column 250 in gauge glass 245 will rise to a level determined by the pressure on the pressure side of the apparatus. By setting the gauge plate with the zero graduation in line with the upper surface of the liquid column 249 a reading may be taken of the height of the liquid column 250 which will indicate the difference of pressure maintained by the apparatus. In order to frictionally hold the scale plate at the desired elevation the slide 247 is provided with elastic clips 251 which bear against ribs 252 on the back of the base plate 237.

The controlling device H for the generator may be of any usual type. It is shown as consisting of a diaphragm casing 253 (Fig. 1) the diaphragm of which operates on a lever 254 pivoted to the diaphragm casing at 255 and connected by a chain 256 with the front damper 257 of the generator. There may also be a chain connected to the furnace pipe damper.

In Fig. 22 I have shown a radiator inlet valve which may be used in place of the radiator inlet valve shown in detail in Fig. 7. The purpose of both valves is the same, to provide means whereby the amounts of steam which the radiators receive will be proportioned to their respective condensing capacities. In the arrangement of Fig. 7 this is accomplished by providing the valves of the several radiators of the system with barrier or orifice plates having orifices properly proportioned, with reference to the position of the radiators in the system, to produce the desired results. In the arrangement shown in Fig. 22 the position of the valve body controlling the inlet port is made to depend upon the difference in pressure as between the supply pipe and the interior of the radiator.

Pressure reducing radiator valve.—Referring to Fig. 22, a pressure reducing valve is connected with the radiator inlet pipe 25 and with radiator C, the means for making the latter connection being those shown in Fig. 7, namely, a nipple 71 screwed into the radiator and a union 70 connecting this nipple with a boss on the valve casing. The valve casing consists of upper and lower members 258, 259, the boss engaged by union 70 being designated 260. Clamped between casing members 258 and 259 is a flexible diaphragm 261. The lower casing member has an inlet port 262 in which is arranged a valve seat 263. A valve body 264 cooperates with seat 263 and is provided with a stem 265 secured to a button 266 to which diaphragm 261 is fastened. A flexible corrugated structure 267 is secured at its lower end to the valve body 264 and at its upper end against a web 268 by means of a cap 269. A corrugated flexible structure 270 is secured at the top between stem members 271, 272 and at the bottom against a web 273 by means of a cap or nut 274. Stem member 271 is threaded for a nut 275 which has a disc-like projection 276 adapted to bear, adjustably, upon a spring 277 which seats upon web 273 above referred to. Steam from the radiator supply pipe 25 can by-pass the valve 263 through duct 278 so as to reach the under side of diaphragm 261. The chamber 279 above the diaphragm is connected with the interior of the radiator C by a pipe 280. Stem member 271 projects into a bonnet 281 on the valve casing. This bonnet is internally threaded to receive the threaded portion 282 of the end of an operating stem 283 which projects through the bonnet and is provided with a hand grip 284. The valve body 264 may be seated on valve seat 263 by turning hand grip 284, but when the valve is not seated in this positive way its position with respect to the valve seat will depend upon the balance of steam pressures on opposite sides of diaphragm 261 and upon the pressure of spring 277 which may be varied by adjustment of nut 275. When the pressure builds up in the radiator to a certain point diaphragm 261 will be deflected downwardly so as to close the inlet port into the radiator or throttle it. When the pressure falls in the radiator the diaphragm will be raised so as to increase the effective size of the inlet port of the radiator.

Summary of operation of the system as a whole.—Steam from the boiler of generator A passes through common supply pipe B and into the several radiators through orifice plates 27 having openings of different sizes proportioned, with respect to the locations of the radiators in the system and their condensing capacities, so that the quantity of steam entering each radiator will be proportioned to the heat demand upon that particular radiator (Fig. 7). A similar result is obtained by providing the radiators with the pressure reducing valves as shown in Fig. 22. The steam is retained in the radiators by steam traps E, E' when operating conditions are such that the radiators are completely filled with steam but air and water of condensation are withdrawn through common return pipe D by the vacuum created in the water tank I through operation of pump M and jet exhauster N. The excess of water drawn into the hurling circuit L from tank I is forced through pipes Y and X into the boiler of the generator. By means of pipe Z the hurling circuit and pump are under boiler pressure so that changes of pressure in the boiler do not affect the operation of the pump. Check valve K on tank I prevents any accumulation of pressure in the tank when the exhausting apparatus is out of operation, through the opening of switch W, and the system is functioning by gravity at pressures slightly above atmospheric pressures. The valve closes inwardly when the tank is under vacuum through operation of the pump. Whenever the water in tank I reaches a certain level, the float 154 closes a circuit through the motor whereupon the pump is started and withdraws water from the tank forcing the same into the boiler of the generator. If the water level in the tank I falls below a certain point the pump is stopped provided the motor circuit is not closed by operation of the pressure differential controller. The pressure differential controller may be made effective or ineffective through the closing or opening of circuit breaker W. With the circuit breaker W closed the differential con-

troller operates to open and close a circuit through the pump motor so as to maintain a certain adjustable difference of pressure as between the supply and return pipes, specifically as between the pressure of the hurling water circuit, which is subject to boiler pressure, and the lower pressure existing in tank I which corresponds to that in the return pipe D. These two controls are independent of each other. Either one will keep the pump motor in operation regardless of the other when conditions require the evacuation of water from tank I or the maintenance of a desired vacuum in the return pipe of the radiating system. Check valve P prevents water from being forced by boiler pressure into tank I when the pump is stopped. Such back flow of water, unless checked, might eventually fill the tank and set the pump in operation.

The maintenance of a constant, but adjustable, difference in pressure between the supply and return mains of the radiating system has several advantages: The introduction of steam into each of the radiators of the system is assured. The amount of steam introduced into the radiators is made dependent solely upon the pressure of steam in the supply pipe and the size of the orifices leading to the several radiators. By properly proportioning the inlet orifices of the radiators and by providing the pressure reducer F in the supply pipe, the maximum amounts of steam received by each radiator (subject to diminution by manual valves 26) will be the same and can be accurately controlled from a central point. Through proper adjustment of the pressure reducer and with properly proportioned radiator orifices, the apparatus can be operated so as to maintain pressures in the radiators either at, above or below atmospheric pressure. This adjustment of pressure in the radiators of the system may be effected automatically through operation of the thermostat G. For example, assuming thermostat G to be located outside of the building, its operation can be controlled (variably by adjustment of weight 101) so that in warm weather for example, the thermostat will cause valves 76, 77 to throttle the steam supply to the radiators to such an extent that with the pump in operation under the differential control, atmospheric or even sub-atmospheric pressure can be maintained in the radiators. Under mild weather conditions the supply of steam may be so reduced that the radiators will be only partially filled with steam; and this condition will necessarily result, with continued reduction of steam supply, after the maximum vacuum has been obtained. As the outside temperature falls more steam will be admitted to the radiators, and this may be enough, for example, in very cold weather, to raise the pressure to atmospheric pressure or to a point above atmospheric pressure. The automatic control of the pump by the controlling mechanism R results in a more uniform control of the supply of steam to the radiators, because the pressure differential is between the return and supply ends of the system instead of being between the return piping and the atmosphere; and also results in an economy of electric current since the pump motor S is in operation only when necessary to maintain the desired conditions. The differential controller maintains a constant pressure differential as between the heating medium in the source of supply of heat, pipe B on the boiler side of the reducing valve F, and the return piping, which differential is sufficient to keep the radiators filled with steam and purged of air and condensate under the severest weather conditions. The pressure reducing valve F under control of the thermostat G reduces, to a greater or less extent, the pressure of steam going to the radiators; the pressure in the supply main B on the radiator side of valve F being regulated by thermostat G so as to supply the radiators with the quantity of steam required by existing heat demands. The operation of the differential controller in conjunction with that of the pressure reducer F maintains as between radiators and return piping pressure differentials which are of less magnitude than that between the source of supply and the return piping and which are proportioned to the quantities of heating medium which must be handled by the system, these differentials being less when the amount of steam circulated is less and greater when the amount of steam circulated is greater. This results in further economy in the operation of the apparatus. The condensate from the radiating system is returned to the boiler of the generator. As the hurling circuit is connected with the boiler both above and below the water line a balanced load is maintained on the boiler regardless of any particular steam pressure therein. The pressure differential may be determined at any time from inspection of the differential gauge and the apparatus adjusted to effect any needed correction.

For nighttime operation the switch W (as shown in full lines in Fig. 15) will ordinarily be open. The differential controller is, therefore, cut out of operation. The pump is operated under the control of the float controlled operator 154 (Fig. 5) to return water accumulated in tank I at suitable intervals to the boiler.

Under these conditions the system will operate at pressures above atmospheric pressure. The pump operates only at intervals and, therefore, does not maintain a constant vacuum in the return piping. If for nighttime operation a lower temperature is desired the weight 101 is shifted to reset the valves 76, 77 to positions closer to their seats. Thereafter the thermostat G operates as before to vary the position of these valves according to temperature changes, whereby the desired lower inside temperature is maintained. The traps will function as in daytime operation. But with the system operating at pressures above atmospheric pressure, check valve K on the tank I will open to permit the outflow of non-condensable gases. The radiators may be either completely or only partially filled with steam according to the quantity of steam supplied to the radiators through operation of controller F.

This application is a continuation in part of my copending application Serial No. 518,386, filed November 28, 1921.

I claim:

1. In heating apparatus, the combination of a generator, a radiating system, supply and return pipes, a water tank, a hurling water circuit under boiler pressure comprising a pump and jet exhauster for withdrawing medium from the return pipe and introducing condensate into the generator, and means for starting and stopping the operation of the pump in response to a decrease or increase, respectively, in the pressure differential between the tank and hurling water circuit.

2. In heating apparatus, the combination of a generator, a radiating system, supply and return pipes, a water tank, a hurling water circuit under boiler pressure comprising a pump and jet ex-

hauster for withdrawing medium from the return pipe and introducing condensate into the generator, means subject to changes in the water level in the tank for controlling the operation of the pump, and means for starting and stopping the operation of the pump in response to a decrease or increase, respectively, in the pressure differential between the tank and hurling water circuit.

3. In heating apparatus, the combination of a generator, a radiating system, supply and return pipes, a water tank, a hurling water circuit under boiler pressure comprising a pump and jet exhauster for withdrawing medium from the return pipe and introducing condensate into the generator, means subject to changes in the water level in the tank for controlling the operation of the pump, means subjected to pressures in the tank and hurling water circuit for controlling the operation of the pump, and means for starting and stopping the operation of the pump in response to a decrease or increase, respectively, in the pressure differential between the tank and hurling water circuit.

4. In an automatically regulated heating system, the combination of heating units each having a restricted inlet opening so proportioned that the quantity of heat carrying medium admitted to the unit can be regulated by variations in pressure in the heat carrying medium, a pressure regulator for varying the pressure in the heat carrying medium, and a temperature controlled regulator for automatically controlling said pressure regulator.

5. In combination in a heating system, a plurality of radiators, a common supply main for supplying heating fluid to said radiators, each radiator being connected to the supply main through a regulable but normally fixed orifice to control the rate of flow to the respective radiators for a given pressure in the supply main, and means responsive to temperature to regulate the pressure of the heating fluid in said mains.

6. In a heating system, the combination of a supply main for heating fluid, a plurality of radiators having connection with said main through orifices for controlling the relative flow of heating fluid to each radiator, a pressure regulator in the supply main for maintaining a given pressure of the heating fluid supplied to said orifices, and means responsive to temperature for controlling the setting of said regulator.

7. In a heating system, a radiator having a fixed orifice to control the inlet of heating fluid thereto, a supply main for heating fluid to be supplied to said orifice, a pressure regulator for holding a predetermined pressure upon said orifice, and temperature responsive means for controlling the setting of said regulator so that the rate of flow of heating fluid through the orifice to the radiator is adjusted to the requirements for heat to be given off by the radiator.

8. In a heating system, the combination of radiators each having a restricted inlet opening so proportioned that the quantity of heat carrying medium admitted thereto can be regulated by variations in the pressure of the heat carrying medium, an automatic pressure regulator for varying the pressure of the heat carrying medium, adjustment varying means for varying the adjustment of said automatic pressure regulator, and temperature controlled means governing said adjustment varying means.

9. In a steam heating system, the combination of radiators each having a restricted inlet opening so proportioned that the quantity of steam admitted thereto can be regulated by variations in the pressure of the heat carrying medium, an automatic regulator for varying the pressure of the steam, and means for automatically varying the setting of the pressure regulator commensurate with variations of temperature.

10. In a heating system, the combination of radiators each having a restricted inlet opening so proportioned that the quantity of heat carrying medium admitted thereto can be regulated by variations in the pressure of the heat carrying medium, an automatic pressure regulator for controlling the pressure in the heat carrying medium, regulable means for varying the setting of the pressure regulator, and temperature controlled means governing such regulable means whereby it may automatically vary the setting of the pressure regulator commensurate with variations in temperature.

11. In a heating system for a building, the combination of a plurality of radiators therein each having a restricted inlet opening so proportioned that the quantity of heat carrying medium admitted thereto can be regulated by variations in the pressure thereof, an automatic regulator for varying the pressure of the heat carrying medium, adjustment varying means for varying the adjustment of said pressure regulator, and thermally sensitive means exposed to variations in temperatures external to the building for governing the adjustment varying means.

12. In a heating system for a building, the combination of a plurality of radiators therein each having an inlet opening so proportioned that the quantity of heat carrying medium admitted thereto can be regulated by variations in the pressure of the heat carrying medium, an automatic pressure regulator for varying the pressure of the heat carrying medium, regulable means for varying the setting of the pressure regulator, and temperature controlled means governing said regulable means whereby it may automatically vary the setting of the pressure regulator commensurate with variations in the atmospheric conditions external to the building.

13. In a heating system, the combination of heating units having each a restricted inlet opening so proportioned that the quantity of heat carrying medium admitted thereto can be regulated by variations in the pressure of the heat carrying medium, a pressure regulator for varying the pressure of the heat carrying medium, means for loading said regulator to a variable degree comprising motor means and a temperature controlled device for governing the action of said motor means.

14. In a heating system, the combination of radiators each having a restricted inlet opening so proportioned that the quantity of heat carrying medium admitted thereto can be regulated by variations in the pressure of the heat carrying medium, an automatic pressure regulator loaded to a variable degree for varying the pressure of the heat carrying medium, means for loading said regulator to a variable degree comprising motor means and a temperature controlled device for governing the action of said motor means.

15. In a heating system for a building, the combination of heating units each having a restricted inlet opening so proportioned that the quantity of heat carrying medium admitted thereto can be regulated by variations in the pressure of the heat carrying medium, a loaded diaphragm pressure regulating valve for automatically regulating the pressure of the heat car-

rying medium, means for varying the loading of said valve comprising motor means and a temperature controlled device subject to temperature outside of the building for governing the action of said motor means.

16. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of a receiver for water of condensation; an exhausting apparatus for withdrawing air and condensate from the radiators and return piping and discharging condensate from said receiver; a differential controller for the exhausting apparatus for maintaining a controlled differential between the pressures in the supply and return piping; and a second controller for the exhausting apparatus which operates in response to differences in water level in the receiver, said exhausting apparatus being started by operation of either controller but stopped only when both controllers are in their stopping positions.

17. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of a receiver for water of condensation; an exhausting apparatus for withdrawing air and condensate from the radiators and return piping and discharging condensate from said receiver; a differential controller for the exhausting apparatus for maintaining a controlled differential between the pressures in the supply and return piping; a second controller for the exhausting apparatus which operates in response to differences in water level in the receiver, said exhausting apparatus being started by operation of either controller but stopped only when both controllers are in their stopping positions; and means whereby the differential controller may be put out of operation and the second controller put into full control of the exhausting apparatus.

18. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping; of a receiver for water of condensation; an exhausting apparatus for withdrawing air and condensate from the radiators and return piping and discharging condensate from the receiver; a controller actuated by steam pressures in the system for controlling the exhausting apparatus; and a second controller for the exhausting apparatus operating, in response to changes in water level in said receiver, said exhausting apparatus being started by operation of either controller but stopped only when both controllers are in their stopping positions.

19. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping; of a receiver for water of condensation; and exhausting apparatus for withdrawing air and condensate from the radiators and return piping and discharging condensate from the receiver; a controller actuated by steam pressures in the system for controlling the exhausting apparatus; a second controller for the exhausting apparatus operating in response to changes in water level in said receiver, said exhausting apparatus being started by operation of either controller but stopped only when both controllers are in their stopping positions; and means whereby the pressure actuated controller may be put out of operation and the second controller put into full control of the exhausting apparatus.

20. In a steam heating system, the combination with a steam generator, a plurality of radiators, and supply and return piping: of a receiver for condensate connected with the return piping; an exhausting apparatus for withdrawing air and condensate from the radiators and return piping, venting the air, and discharging condensate from the receiver back to the generator; a controller responsive to pressure changes in the system for starting and stopping the exhausting apparatus; and a second controller for starting and stopping the exhaust apparatus in response to changes in the liquid level in the receiver, said exhausting apparatus being started by operation of either controller but stopped only when both controllers are in their stopping positions.

21. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of a receiver for condensate; an exhausting apparatus for withdrawing air and condensate from the radiators and return piping and discharging condensate from the receiver; controlling means for said exhausting apparatus responsive to changes of liquid level in the receiver and also to changes in pressure differential between the supply and return piping so that the exhausting apparatus will be set in operation when either the liquid in the receiver reaches a certain level or when said pressure differential falls below a predetermined minimum, and will continue to operate until both the desired liquid level and the desired pressure differential have been reestablished.

22. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of a receiver for condensate; an exhausting apparatus for withdrawing air and condensate from the radiators and return piping and discharging condensate from the receiver; controlling means for said exhausting apparatus responsive to changes of liquid level in the receiver and also to changes in pressure differential between the supply and return piping so that the exhausting apparatus will be set in operation when either the liquid in the receiver reaches a certain level or when said pressure differential falls below a predetermined minimum, and will continue to operate until both the desired liquid level and the desired pressure differential have been re-established; and means for rendering the pressure control of the exhausting apparatus ineffective and making the exhausting apparatus subject only to control by changes in liquid level.

23. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of steam traps at the outlets of said radiators; means comprising an exhausting mechanism for maintaining a controlled differential between the pressures in the supply and return piping, means comprising a valve actuated by pressure in the supply piping for controlling the flow of steam to the radiators, and a thermostat acting on said valve in a manner to meet varying heat requirements of the system.

24. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means for restricting the flow of steam into the radiators in proportion to their individual heat requirements; means actuated by pressures in the supply and return piping for maintaining a controlled differential between the pressures in the supply and return piping and means for varying said differential in a manner to meet the heat requirements of the system as a whole.

25. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of orifice plates, the orifices of which are proportioned so as to restrict the flow of steam into the radiators in proportion to their individual heat requirements; steam traps at the outlets of said radiators; and means comprising an exhausting mechanism and a thermostat subject to temperatures external to the system, for maintaining controlled differentials between the pressures in the supply and return piping which are variable to meet the heat requirements of the system as a whole.

26. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means actuated by pressures in the supply and return piping for maintaining a substantially constant pressure differential between the source of steam supply and return piping; and controlling means in the supply piping for maintaining determinable pressure differentials, of less magnitude than that between supply and return piping, between the pressures in the radiators and return piping.

27. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means actuated by pressures in the supply and return piping for maintaining a substantially constant pressure differential between the source of steam supply and the return piping; and thermostatically controlled means in the supply piping for maintaining determinable pressure differentials, of less magnitude than that between supply and return piping, between the pressures in the radiators and return piping.

28. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means actuated by pressures in the supply and return piping for maintaining a substantially constant pressure differential between the source of steam supply and the return piping and controlling means for determining the pressure of steam supplied to the radiators in response to the heat requirements of the system.

29. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means actuated by pressures in the supply and return piping for maintaining a substantially constant pressure differential between the source of steam supply and the return piping and a thermostatically controlled means for maintaining determinable pressure differentials, of less magnitude than that between supply and return piping, between the pressures in the radiators and return piping.

30. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means for maintaining controllable pressures in the source of steam supply; means actuated by pressures in the supply and return piping for maintaining a substantially constant pressure differential between the source of steam supply and the return piping; and controlling means in the supply piping for maintaining determinable pressure differentials, of less magnitude than that between supply and return piping, between the pressures in the radiators and return piping.

31. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping; of means for retaining steam in the radiators while permitting the outflow of air and condensate therefrom; means actuated by pressures in the supply and return piping, comprising an exhausting mechanism, for maintaining a substantially constant pressure differential between the source of supply and the return piping; and controlling means in the supply piping for maintaining determinable pressure differentials, of less magnitude than that between supply and return piping, between the pressures in the radiators and return piping.

32. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means for retaining steam in the radiators while permitting the outflow of air and condensate therefrom; means actuated by pressures in the supply and return piping comprising an exhausting mechanism, for maintaining a substantially constant pressure differential between the source of supply and the return piping; and controlling means for maintaining determinable pressure differentials, of less magnitude than that between supply and return piping, between the pressures in the radiators and return piping.

33. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means for retaining steam in the radiators while permitting the outflow of air and condensate therefrom; means actuated by pressures in the supply and return piping, comprising an exhausting mechanism, for maintaining a substantially constant pressure differential between the source of supply and the return piping; and thermostatically controlled means in the supply piping for maintaining determinable pressure differentials, of less magnitude than that between supply and return piping, between the pressures in the radiators and return piping.

34. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means actuated by supply and return pipe pressures for maintaining a controlled differential between the pressures in the supply and return piping means including a valve between the source of supply and the radiators influenced by pressure in the supply piping for retarding to a greater or less extent the flow of steam between the source of supply and the radiators; and thermostatic means subject to temperatures external to the system, for additionally controlling the flow of steam to the radiators in accordance with the heat requirements of the system.

35. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means for maintaining a substantially constant pressure in the source of steam supply; means actuated by supply and return pipe pressures for maintaining a controlled differential between the pressures in the supply and return piping; means including a valve between the source of supply and radiators influenced by pressure in the supply piping for retarding, to a greater or less extent, the flow of steam between the source of supply and the radiators, and thermostatic means for additionally controlling the flow of steam to the radiators in accordance with the heat requirements of the system.

36. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means actuated by supply and return pipe pressures for maintaining a controlled differential between the

pressure in the supply and return piping; a thermostatically operated valve mechanism in the supply piping between the source of steam supply and the radiators and influenced by pressure in the supply piping which is capable of closing to shut off steam supply to the radiators or being opened to a greater or less extent, for additionally controlling the flow to the radiators in accordance with the heat requirements of the system.

37. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means for maintaining steam in the radiators while permitting the outflow of air and condensate; an exhausting apparatus for withdrawing fluids from said radiators and return piping; pressure responsive means controlling the exhausting apparatus to maintain a controlled differential between the pressures in the source and return piping; and a pressure reducer in the supply piping for determining the quantities of steam supplied to and the pressures maintained in the radiators, regardless of fluctuations of pressure in the source of steam supply, in accordance with the heat requirements of the system.

38. In a steam heating system, the combination with a source of steam supply, a plurality of radiators, and supply and return piping: of means for maintaining steam in the radiators while permitting the outflow of air and condensate; an exhausting apparatus for withdrawing fluids from said radiators and return piping; pressure responsive means controlling the exhausting apparatus to maintain a controlled differential between the pressures in the source and return piping; a pressure reducer in the supply piping for maintaining at a selected pressure, regardless of fluctuations of pressure in the source of supply, the quantities of steam delivered to and the pressures maintained in the radiators; and thermostatic means actuating said pressure reducer for determining said selected pressure in response to the heat requirements of the system.

39. In a steam heating system, the combination of a source of steam supply; a plurality of radiators having fixed restricted inlet orifices of such sizes that the radiators receive quantities of steam proportioned to their individual heat requirements; supply and return piping; thermostatic means for controlling the pressure of steam in the supply piping adjacent the radiator inlets in accordance with the heat requirements of the system as a whole; and means cooperating with the thermostatic means for maintaining a controlled differential between the pressures in the supply and return piping.

40. In a steam heating system, the combination of a source of steam supply; a plurality of radiators having fixed restricted inlet orifices of such sizes that the radiators receive quantities of steam proportioned to their individual heat requirements, and being provided at their outlets with steam traps; supply and return piping; thermostatic means for controlling the pressure of steam in the supply piping adjacent the radiator inlets in accordance with the heat requirements of the system as a whole; and means cooperating with the thermostatic means and comprising an exhausting apparatus for maintaining a controlled differential between the pressures in the supply and return piping.

41. In a steam heating system, the combination of a source of steam supply; a plurality of radiators having fixed restricted inlet orifices of such sizes that the radiators receive quantities of steam proportioned to their individual heat requirements; supply and return piping; thermostatic means, subject to temperatures external to the system, for controlling the pressure of steam in the supply piping adjacent the radiator inlets in accordance with the heat requirements of the system as a whole; and means cooperating with the thermostatic means for maintaining a controlled differential between the pressures in the supply and return piping.

42. In a steam heating system, the combination of a source of steam supply; a plurality of radiators having fixed restricted inlet orifices of such sizes that the radiators receive quantities of steam proportioned to their individual heat requirements; supply and return piping; thermostatic means, subject to temperatures external to the space being heated, for controlling the pressure of steam in the supply piping adjacent the radiator inlets in accordance with the heat requirements of the system as a whole; and means cooperating with the thermostatic means for maintaining a controlled differential between the pressures in the supply and return piping.

43. In a steam heating system, the combination of a source of steam supply; a plurality of radiators having fixed restricted inlet orifices of such sizes that the radiators receive quantities of steam proportioned to their individual heat requirements, and provided at their outlets with steam traps; supply and return piping; thermostatic means subject to temperatures external to the system for controlling the pressure of steam in the supply piping adjacent the radiator inlets in accordance with the heat requirements of the system as a whole; and means cooperating with the thermostatic means and comprising an exhausting apparatus, for maintaining a controlled differential between the pressures in the supply and return piping.

44. In a steam heating system, the combination of a steam generator; a plurality of radiators provided at their inlets with orifice plates, the orifices of which are proportioned so that the radiators receive steam in proportion to their individual heat requirements; steam traps at the outlets of said radiators; supply and return piping; an exhausting apparatus for withdrawing air and condensate from the radiators and return piping; a pressure reducer in the supply piping which maintains determinate pressures in the radiator inlets regardless of fluctuations in generator pressure; and a controller for the exhausting apparatus cooperating with the pressure reducer for maintaining a controlled differential between the pressures in the supply and return piping.

45. In a steam heating system, the combination of a steam generator; a plurality of radiators provided at their inlets with orifice plates, the orifices of which are proportioned so that the radiators receive steam in proportion to their individual heat requirements; steam traps at the outlets of said radiators; supply and return piping; an exhausting apparatus for withdrawing air and condensate from the radiators and return piping; a pressure reducer in the supply piping which maintains determinate pressures at the radiator inlets regardless of fluctuations in generator pressure; and a thermostat to control said pressure reducer, and a controller for the exhausting apparatus cooperating with the pressure reducer for maintaining a controlled differential between the pressures in the supply and return piping.

46. In an automatically regulated steam heating system, the combination of supply and return pipes, heating units, each having a restricted inlet opening so proportioned that the quantity of heat carrying medium admitted to the unit can be regulated by variations in pressure in the heat carrying medium, a pressure regulator for varying the pressure in the heat carrying medium, a temperature controlled regulator for automatically controlling said pressure regulator, and exhausting means for maintaining a lower pressure in the return pipe than in the supply pipe.

47. In an automatically regulated steam heating system, the combination of supply and return pipes, radiators each having a restricted inlet opening so that the quantity of heat carrying medium admitted to the unit can be regulated by variations in pressure in the heat carrying medium, and each provided at its outlet with a steam trap to prevent the escape of steam while permitting the discharge of water of condensation and air, a pressure regulator for varying the pressure in the heat carrying medium, a temperature controlled regulator for automatically controlling said pressure regulator, and an exhausting means for maintaining a lower pressure in the return pipe than in the supply pipe.

CLAYTON A. DUNHAM.

CERTIFICATE OF CORRECTION.

Patent No. 1,983,218. **December 4, 1934.**

CLAYTON A. DUNHAM.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 8, lines 17, 18 and 19, claim 3, strike out the words and comma "means subjected to pressures in the tank and hurling water circuit for controlling the operation of the pump,"; and line 23, of said claim, after "circuit" insert the words and means for preventing the escape of steam from the radiating system while permitting the outflow of water and air therefrom; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 12th day of February, A. D. 1935.

Leslie Frazer
Acting Commissioner of Patents.

(Seal)

46. In an automatically regulated steam heating system, the combination of supply and return pipes, heating units, each having a restricted inlet opening so proportioned that the quantity of heat carrying medium admitted to the unit can be regulated by variations in pressure in the heat carrying medium, a pressure regulator for varying the pressure in the heat carrying medium, a temperature controlled regulator for automatically controlling said pressure regulator, and exhausting means for maintaining a lower pressure in the return pipe than in the supply pipe.

47. In an automatically regulated steam heating system, the combination of supply and return pipes, radiators each having a restricted inlet opening so that the quantity of heat carrying medium admitted to the unit can be regulated by variations in pressure in the heat carrying medium, and each provided at its outlet with a steam trap to prevent the escape of steam while permitting the discharge of water of condensation and air, a pressure regulator for varying the pressure in the heat carrying medium, a temperature controlled regulator for automatically controlling said pressure regulator, and an exhausting means for maintaining a lower pressure in the return pipe than in the supply pipe.

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