June 19, 1934. D. N. CROSTHWAIT, JR 1,963,735

METHOD OF STEAM HEATING FROM CENTRAL STATION MAINS

Filed Aug. 27, 1931 3 Sheets-Sheet 1

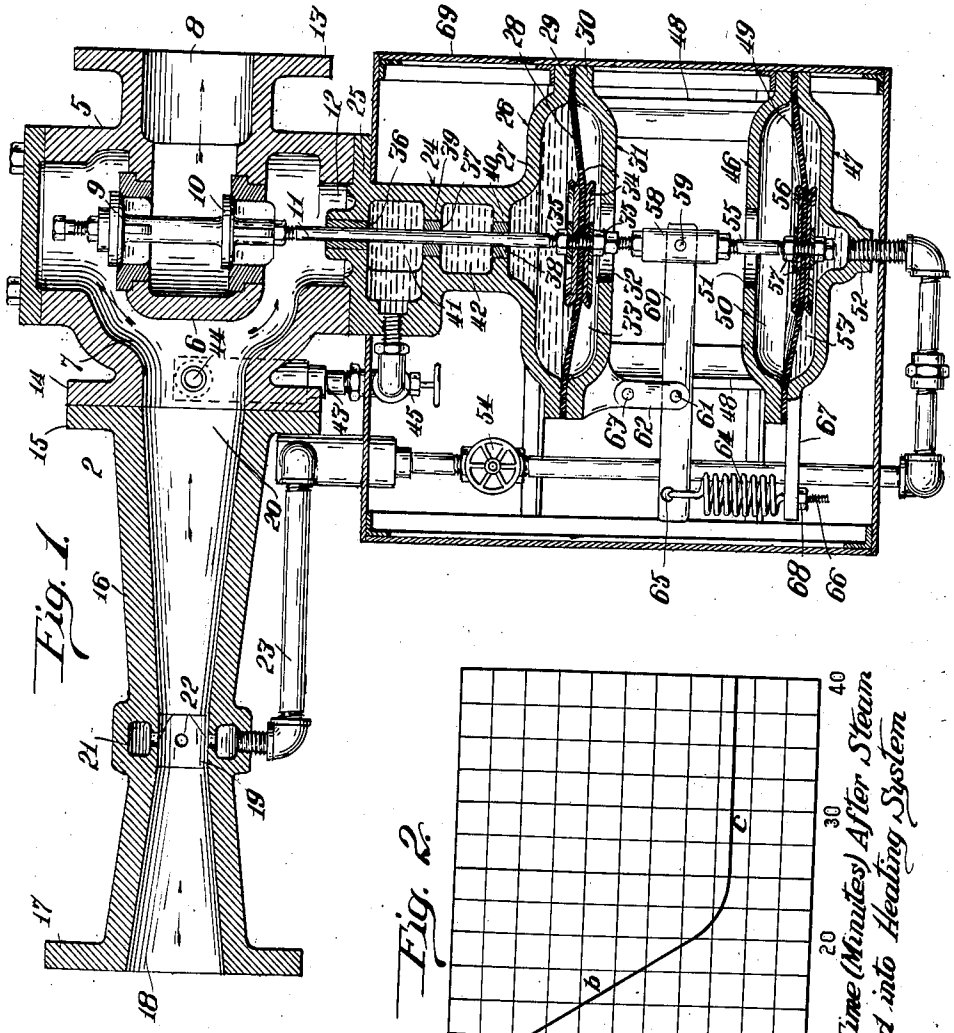


Fig. 1.

Fig. 2.

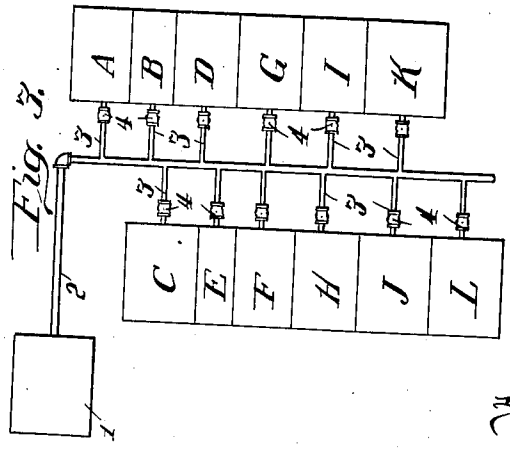


Fig. 3.

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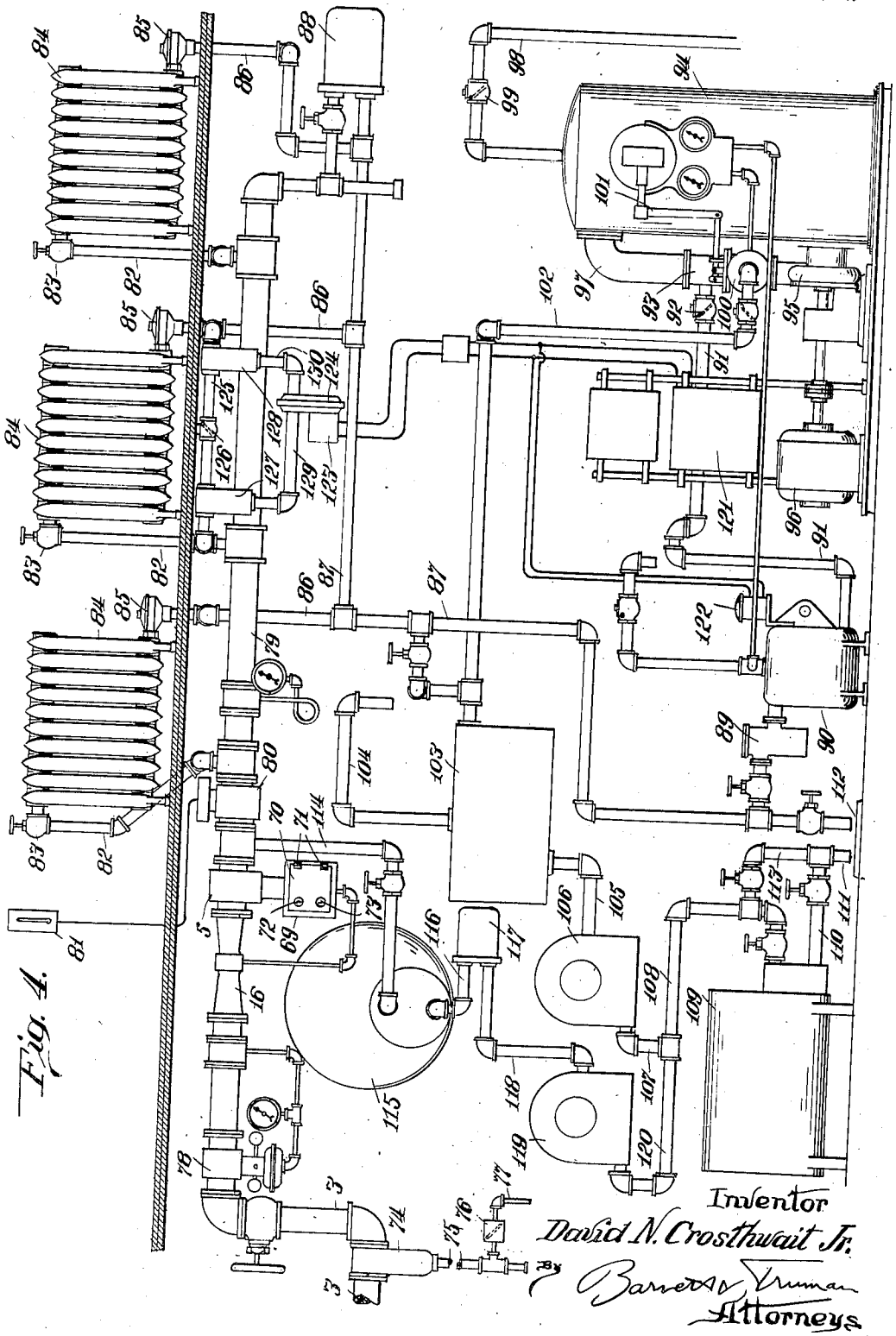


Fig. 4.

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Filed Aug. 27, 1931 3 Sheets-Sheet 3

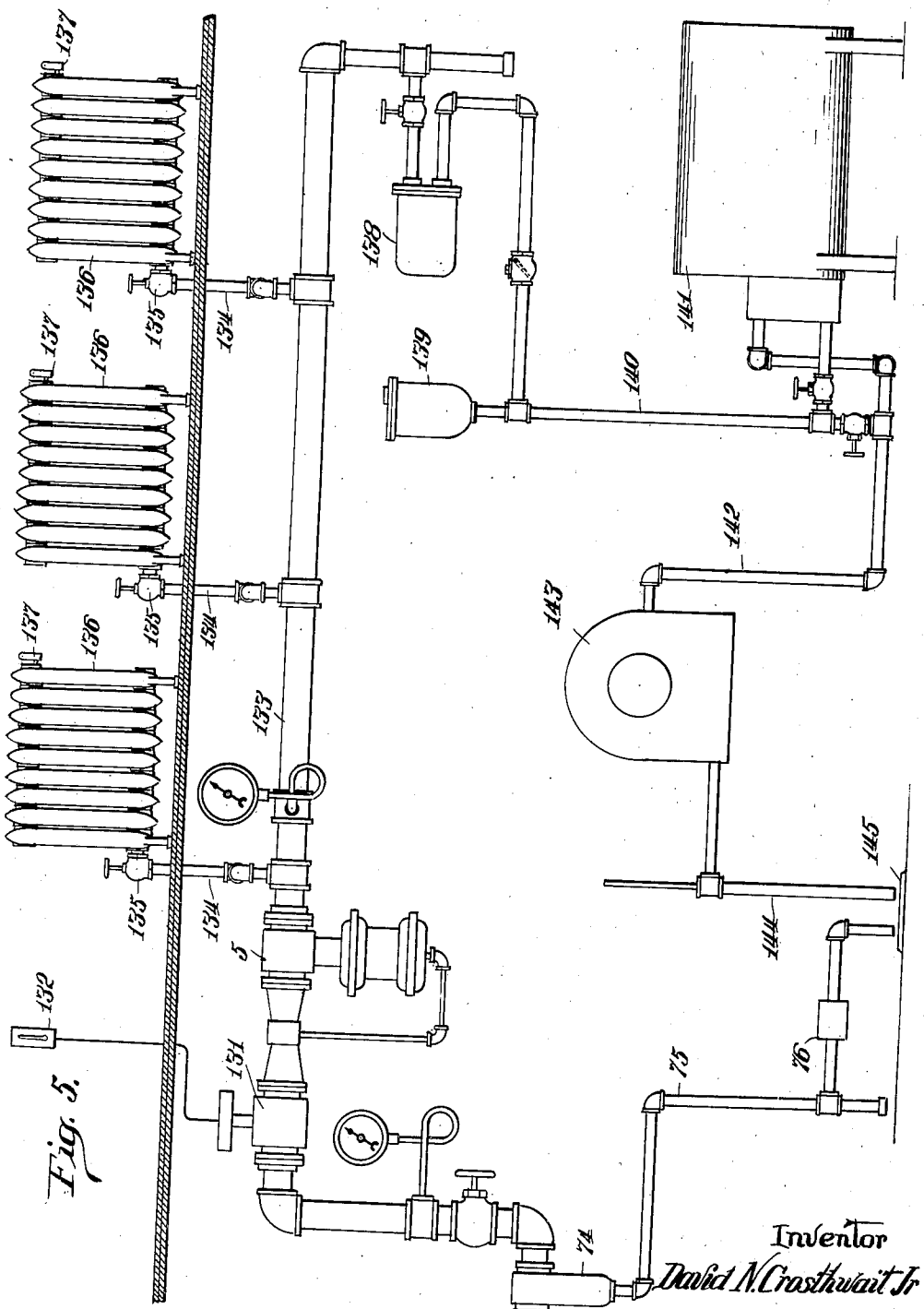


Fig. 5.

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METHOD OF STEAM HEATING FROM CENTRAL STATION MAINS

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Application August 27, 1931, Serial No. 559,738

7 Claims. (Cl. 237—12)

This invention relates to certain new and useful improvements in a method and apparatus for steam heating from central station mains, and more particularly to an improved method and means for increasing the normal operating efficiency of the steam supply main, that is increasing the number of heating systems or the size of the connected load that may be satisfactorily supplied with steam from a main or supply pipe of any given size.

A steam pipe of a given size and a given length, supplied with steam at a given initial pressure, has a given capacity for any given difference of pressure between the entrance to the said steam main and its end. This determined maximum steam flow or capacity of the supply main must be capable of meeting the maximum requirements of the several heating systems or connected load supplied therefrom, and it will be apparent that these maximum requirements determine the number or size of the heating systems or the size of the connected load that can be supplied from a main of any given capacity. When a steam heating system which forms the connected load or a part of the connected load of a steam heating main is turned on after having been out of operation, the demand during the initial heating up period greatly exceeds the normal demand, that is the maximum demand that obtains after the heating apparatus and the building heated thereby have been brought up to approximately the desired temperature.

According to the present invention, means is provided in each branch conduit or in advance of each portion of the connected load which is directly supplied from the steam main for limiting the maximum steam flow through this branch conduit to a rate substantially sufficient to satisfy the normal maximum requirements after that particular system has been brought up to temperature. In this manner the excessive initial steam demand which would be imposed on the supply main when any relatively cold heating system is first connected up with the supply main, after having been out of service, will be eliminated. This separate heating system or portion of the connected load will be more slowly brought up to temperature, but no excessive temporary demands will be made upon the supply main and consequently the number of heating systems or the size of the connected load, that can be satisfactorily and constantly furnished with steam from the one central source is greatly increased.

The principal object of this invention is to provide an improved method for increasing the effective capacity of central station steam heating mains, such as briefly described hereinabove and disclosed more in detail in the specifications which follow.

Another object is to provide an improved means for controlling the rate of steam flow through a conduit of a steam heating system.

Another object is to provide a steam flow controller operated by the pressure differential resulting from changes in the rate of steam flow through a conduit.

Another object is to provide improved means for controlling the rate of steam flow through a conduit, said means being provided with packingless operating means.

Another object is to provide improved means for locking or preventing unauthorized access to an adjustable controller for regulating the rate of steam flow through a conduit.

Other objects and advantages of this invention will be more apparent from the following detailed description of certain approved forms of mechanism operating according to the principles of this invention.

In the accompanying drawings:

Fig. 1 is a central vertical section through the improved steam-flow controller.

Fig. 2 is a chart illustrating the relation of the condensing rate to the elapsed time after steam is turned into a radiator or other heating apparatus.

Fig. 3 is a diagrammatic view illustrating the component parts of a heating system comprising a plurality of separate buildings heated from a central supply main.

Fig. 4 is a diagrammatic elevation showing one type of steam heating system with which the improved steam flow controller may be advantageously used.

Fig. 5 is a diagrammatic elevation similar to Fig. 4 showing the application of the flow controller to another type of steam heating system.

Referring first to the chart shown in Fig. 2, the line *a—b—c* illustrates the changes in the condensing rate within a radiator or other heating system after the steam supply is first turned on and before the heating apparatus and the building and space heated thereby is brought up to the desired temperature. Tests have shown that during approximately the first ten minutes, the condensing rate may increase (as indicated by the portion *a* of the line) to approximately four times the normal condensing rate *c* that will prevail after the apparatus has been brought up to temperature and under some conditions the con-

densing rate may even exceed this value for a short time. After reaching this maximum, the rate gradually diminishes, as indicated at *b*, until at some subsequent time the normal condensing rate *c* is established. It is essential that the central supply main be capable of supplying the maximum demands of the individual heating systems supplied therefrom, therefore this central supply main must be capable of supplying a maximum indicated by the peak *a*—*b*, although the normal maximum demand of the system will only be approximately one-fourth of this amount, as indicated by the normal condensing rate *c*. If, therefore, the maximum rate of steam flow into the system is limited so that it can never exceed an amount sufficient to substantially supply the normal condensing rate *c*, the maximum demands of the system will be reduced to one-fourth of the amount represented by the peak *a*—*b*, and approximately four times as many heating systems, or a connected load four times as great may be supplied from the same central heating main. According to the present invention, a steam flow rate controller is provided between the supply main and each individual heating system, or in each branch main leading to a separate portion of the connected load so as to limit the maximum rate of steam flow to this individual system to the normal requirements of this system, even though the temporary demand of the system (as for example when the system is first put into service) shall call for a greater flow of steam. As a consequence, somewhat more time is required to bring any individual system up to the desired temperature, but the load imposed upon the boiler is never so suddenly or excessively increased that there is danger of a sudden and excessive reduction of the boiler water line, and the number of systems, or the size of the connected load that may be supplied from the same boiler or central heating plant is greatly increased.

Referring now to the diagram shown in Fig. 3, the central heating plant or boiler indicated at 1, supplies steam through the central main 2, from which branches 3 lead to the separate heating systems in the several buildings indicated at A to L inclusive. If this supply main 2 must meet (as is the usual practice) the maximum initial steam requirements of the systems supplied therefrom, we will say that the size of supply main illustrated is only sufficient to meet the demands of the three heating systems indicated at A, B and C. If, however, the improved steam flow controllers indicated diagrammatically at 4, and hereinafter disclosed in detail, are introduced in advance of each heating system so as to reduce the maximum steam flow into each system to an amount substantially sufficient to meet the maximum requirements of that system after it is brought up to working temperature, a plurality of additional heating systems, such as indicated by D to L inclusive may also be supplied from the same size of central supply main 2. It is to be understood that the proportions here given are merely approximate and are disclosed by way of example to illustrate the principles involved.

Reference will now be made to Fig. 1 which illustrates one approved form of steam flow controller suitable, when used in connection with other elements of a heating system, for carrying out the principles of this invention. The valve casing 5 is formed with an interior web 6 which divides the inlet chamber 7 from the outlet chamber 8. A pair of balanced or semi-balanced valves 9 and 10 control valve openings in the web 6 and are carried by a valve stem 11 which projects downwardly through the opening 12 in the bottom of casing 5. The casing 5 is provided with an attaching flange 13 around the outlet 8 for connection to the pipe or conduit to which the steam is supplied. At its inlet end the casing 5 is provided with a flange 14 for attachment to a corresponding flange 15 at the exit end of a Venturi tube 16 provided at its inlet end with a flange 17 for attachment to the supply conduit. The Venturi tube is of usual construction comprising an expanded inlet 18, a central contracted throat portion 19 and an expanded outlet or exit opening 20 which leads into the valve housing 5. Surrounding the restricted throat portion 19 is an annular passage 21 which communicates with the throat through a plurality of openings 22, and from which leads the pressure pipe 23. It will be understood that steam flows through this assembly in the direction of the arrows, entering through the expanded inlet 18 of the venturi, thence passing through the restricted throat 19 and out through the expanded exit 20 into the inlet chamber 7 of the valve casing 5, thence through the valve openings controlled by valves 9 and 10 and through the outlet chamber 8.

A casting 24 is secured to the lower side of valve housing 5 and comprises an upper closure plate 25 for the opening 12 in the bottom of inlet chamber 7, and a lower bell-shaped portion 26 which cooperates with the flexible diaphragm 28 to enclose a pressure chamber 27. The flexible diaphragm 28 is clamped at its outer edges between the peripheral flange 29 of housing 26 and the similar flange 30 of a lower housing member 31 which is open at its central portion 32 so that atmospheric pressure will prevail in the chamber 33 beneath the diaphragm 28. The valve stem 11 projects through the central portion of diaphragm 28 and is sealed thereto by means of the diaphragm plates 34 and the clamping nuts 35. The valve stem 11 projects through a guide bushing 36 in the closure plate 25 and also through bushings 37 and 38 in the webs 39 and 40 formed in casting 24. These bushings 37 and 38 have a sufficiently loose fit about the stem 11 so that substantially the same pressures will prevail in the chambers 41 and 42 as in the diaphragm chamber 27, and a free passage of fluids is permitted between these chambers. The bushing 36 may have as close a fit as desired in order to properly guide the stem 11, but since the pressure in chamber 41 is substantially the same as in the inlet chamber 7, there is no necessity that this bushing be fluid tight. A pressure pipe 43 leads from an opening 44 in inlet chamber 7 adjacent the outlet 20 of the venturi, into the chamber 41, and thence communicates through chamber 42 with the diaphragm chamber 27. It will thus be apparent that the pressure existing in diaphragm chamber 27 will be governed directly by the pressure existing at the outlet 20 of the venturi. Pressure tube 43 may be provided with a cut-off valve, indicated at 45.

A second diaphragm housing comprising the members 46 and 47 is supported by struts 48 depending from the upper housing member 31. A second flexible diaphragm 49, similar in all respects to the upper diaphragm 48, is clamped between the housing members 46 and 47, the chamber 50 above this diaphragm being open to the atmosphere through the central opening 51 in casing member 46. The pressure pipe 23 leading from the restricted throat of Venturi tube 16 communicates at 52 with the chamber 53 beneath

liaphragm 49, which chamber is otherwise closed, so that the pressure prevailing in this chamber 53 will be approximately the same as the pressure in annular space 21 surrounding the restricted throat 19 of the venturi. A cut-off valve 54 may be provided in the pressure pipe 23.

An extension 55 of valve stem 11 projects downward through opening 51 and is sealed to the lower diaphragm 49 by means of diaphragm plates 56 and clamping nuts 57. In a housing or yoke 58 provided in the portion of the valve stem between the two diaphragms, one end of a lever 60 is pivotally connected at 59, the lever being intermediately pivoted at 61 to a fulcrum link 62 supported at 63 from the casing 31. The upper end of a tension spring 64 is secured at 65 to the opposite arm of lever 60, the lower threaded end 66 of this spring projecting through an arm 67 on the lower housing member 47 and being provided with an adjusting nut 68, whereby the tension of the spring may be determined. It will now be apparent that this spring 64, acting through lever 60, tends to push the valve stem 11 upwardly and thus open the valves 9 and 10.

The diaphragms 28 and 49 are of similar size and atmospheric pressure always prevails in the opposed diaphragm chambers 33 and 50. When there is no steam flow through the Venturi tube and valve housing, the same pressure will prevail in the restricted throat 19 of the venturi as exists at the outlet 20, therefore the same pressures will prevail in the upper and lower diaphragm chambers 27 and 53 and there will be no pressure differential exerted on valve stem 11 tending to either open or close the valves. However, as is well known, when fluids flow through the restricted throat 19 of the Venturi tube, the velocity of the fluids will be increased at this location and the pressure will be decreased, that is, there will be a suction exerted through openings 22 on the annular chamber 21, whereby the pressure in this chamber, and consequently the pressure in lower diaphragm chamber 53, which is in communication with chamber 21 through pipe 23, will be lowered. The decrease in pressure in chamber 53 will vary in accordance with the increase in the rate of steam flow through the Venturi tube 16. It will also be noted that the pressure differential between the throat 19 and the exit 20 of the venturi will be substantially independent of the absolute pressure of the steam passing through the conduit system, that is the pressure differential which controls the operation of the valve will be substantially independent of fluctuations in the absolute pressure of the steam, the rate of flow of which is to be controlled.

In operation the valves 9 and 10 will normally be held open by spring 64 so as to permit a free flow of steam through the venturi 16 and valve housing 5. However, as the rate of steam flow through the Venturi tube is increased, the pressure in diaphragm chamber 53 will be correspondingly lowered so as to increase the pressure differential existing between this chamber and the upper diaphragm chamber 27 which is always subject to the steam pressure existing in inlet chamber 7 adjacent the outlet 20 of the venturi. When this rate of steam flow reaches a predetermined maximum, the pressure differential will become sufficient to overcome the force of spring 64 and move valves 9 and 10 against their seats to cut off the flow of steam through the valve housing. In actual operation the valves will be brought to a partially closed position so as to determine a maximum rate of steam flow through the assembly without ordinarily entirely cutting off the flow of steam. By adjusting the tension of spring 64, the maximum rate of steam flow controlled by this valve may be pre-determined within certain limits.

It is desirable that the adjustment of this device should not be tampered with by unauthorized persons. To prevent this the operating assembly including the adjusting mechanism for spring 64 and the valves 45 and 54 may be enclosed in a casing 69. As indicated in Fig. 4, this casing 69 may be provided with a closure 70 hinged to the casing at 71, and provided with a pair of separate and independent locking mechanisms 72 and 73. These may conveniently be Yale locks, the key to one of which is retained by the night operator and the other by the day operator. It will thus be impossible for either operator to change the adjustments without the knowledge and co-operation of the other.

In Figs. 4 and 5 are illustrated, by way of example, two different types of steam heating systems in which this improvement may be incorporated. Systems receiving their steam supply from a central station steam main usually use some temperature control means for promoting economy and maintaining the desired temperature. The location of this temperature control means is optional and may be located either beyond the flow-controller, as indicated in Fig. 4, or in advance of it, as indicated in Fig. 5.

Reference will first be made to Fig. 4 which illustrates a sub-atmospheric differential-pressure steam heating system of the general type disclosed in the patent to Clayton A. Dunham, No. 1,644,114, granted October 4, 1927. At 3 is indicated the branch steam supply main leading from the main central supply conduit. In this supply pipe 3 may be positioned a steam separator 74 from which leads a pipe 75 provided with a steam trap 76 and an extension 77 through which condensate flows to the sewer. The improved flow-controller is positioned in main 3, as indicated at 5 and 16 (these being the same reference characters as used in Fig. 1 to indicate the valve housing and venturi, respectively.) If desired, a pressure reducing valve 78 of any approved type may be positioned in main 3 in advance of the flow-controller. The pressure carried in the central supply main 2 may be quite high, for example as much as 40 pounds per square inch. It is undesirable to reduce this steam pressure down to sub-atmospheric pressures in a single step, and furthermore if sub-atmospheric pressures are used in the improved flow-controller 5, very large sizes will be required. Accordingly, the pressure reducer 78 may be used to reduce the steam pressure down to, for example, 3 to 5 pounds per square inch, at which pressure the steam flows through the rate-controller 5. Beyond this rate-controller, the sub-atmospheric pressure of the steam in the portion 79 of the supply main is determined by the throttling type temperature control valve 80, which may be under the control of a thermostat indicated at 81. The sub-atmospheric pressure steam flows from main 79 through risers 82 and inlet valves 83 into the several radiators 84, provided at their outlets with steam traps 85, from which return pipes 86 lead into the common return main 87, through which condensate and non-condensable gases are drawn out from the radiators. At 88 is indicated a combination float and thermostatic trap interposed between the

end of supply main 79 and the return main 87. The condensate and gases pass through strainer 89 into accumulator tank 90, from which they are withdrawn through pipe 91 provided with check valve 92 into the ejector 93. The exhausting mechanism comprises a separator tank 94, from which centrifugal pump 95 driven by motor 96 withdraws a stream of water which is forced through ejector 93 and returned through discharge pipe 97 into the upper portion of the separating tank 94 along with the condensate and non-condensable gases withdrawn from the heating system through pipe 91. The gases are vented through pipe 98 provided with outwardly opening check valve 99. When a certain quantity of condensate has accumulated within tank 94, a valve 100 operated through lever and link mechanism 101 from a float within tank 94 opens to permit the pump to force out the excess liquid through pipe 102 into the separating tank 103 provided with a gas vent at 104, the water flowing through pipe 105 into and through meter 106, thence through pipes 107 and 108 into the economizer 109. After a certain amount of the remaining heat has been withdrawn in the economizer 109, the water flows through pipe connections 110 and 111 into the sewer connection, indicated at 112. If desired, the water can be passed directly from meter 106 through pipes 107 and 108 and the shunt pipe 113 to the sewer without passing through the economizer. The economizer 109 may take a variety of well known forms, for example, it may be used to pre-heat the domestic hot water supply, or may be used as an auxiliary radiator. Its purpose, of course, is to prevent the unnecessary waste of heat carried out by the water passing to the sewer.

If desired, water may be heated by means of steam taken directly from the branch main 79, the steam flowing through pipe 114 into the heater 115, and the condensate passing out through pipe 116, trap 117 and pipe 118 to and through the meter 119, thence through pipes 120 and 108 to the economizer 109.

The pump motor 96 is controlled from a starter 121, in the control circuit of which is a switch 122 actuated by a float in accumulator tank 90, and a second switch 123 operated by a differential-pressure controller 124. A shunt pipe 125 is connected between the supply and return sides of the system, as here shown between the riser 82 and return pipe 86 of one of the radiators. In this pipe 125 is a check-valve 126 opening toward the normally high-pressure side of the system so that pipe 125 will function as an equalizing pipe in case the pressure in the supply side of the system should, for any reason, fall below the pressure then existing in the return pipes. A pair of surge tanks 127 and 128 located, respectively, in the high and low pressure branches of pipe 125 are connected by pipes 129 and 130 with the chambers at the two sides of the diaphragm in differential controller 124. When a certain predetermined pressure-differential has been established between the high and low pressure sides of the system (sufficient to insure the flow of fluids through the radiators), differential controller 124 operates to open switch 123. When the pressure differential falls below this predetermined value, the switch 123 will be automatically closed to again start motor 96 and the exhausting mechanism driven thereby into operation. The exhausting mechanism will also be caused to operate, by the closing of switch 122, whenever a predetermined amount of liquid has accumulated in tank 90.

Referring now to the general operation of this heating system, when the building and apparatus is cold and the system has been out of service for a period of time, the control valve 80 will be wide open, and the reducing valve 78 will also remain open until a certain reduced steam pressure has been built up throughout the heating system. As a consequence (unless the flow-controller 5 is used) there will be an excessive initial rush of steam into the system and this excessive drain on the supply main will continue for a period of time, due to the very high condensing rate throughout the system until the radiators and connecting piping become heated up to substantially the normal working temperature. This excessive rate of steam flow will continue until the radiators 84 become filled with steam at the predetermined sub-atmospheric pressure and the traps 85 have closed, after which steam will only be supplied at a rate sufficient to balance the normal condensing rate within the radiators.

With the flow controller 5 installed, steam can at no time flow into the system at a rate substantially greater than that required during the normal operation after the system has been brought up to temperature. As a consequence, a somewhat longer time is required to bring the heating system up to temperature, but the advantage is gained that at no time is an excessive or dangerous drain placed upon the central steam supply main 2, the peak of the load is more evenly distributed, the boiler may be operated more efficiently, and a central distributing main of given size is capable of supplying steam to a much larger number of distributing systems or in other words is capable of carrying a much larger connected load.

As an example of another type of steam-heating system with which this controller may be used, in Fig. 5 is shown a one-pipe heating system which will ordinarily use steam at superatmospheric pressures. Many of the parts here shown correspond to those illustrated in Fig. 4 and will not be referred to in detail. The steam flows in through the branch supply main 3 in which is positioned the control valve 131 operated by thermostat 132. Beyond this control valve 131 is positioned the flow-controller 5 which operates in the same manner as hereinabove described. The steam then flows from supply main 133 through risers 134 and inlet valves 135 into the radiators 136, the condensate flowing back through the same risers 134 into the combined supply and drip pipe 133. Gases are vented from the radiators through the valves 137, of usual types. The fluids flow out through trap 138 into return pipe 140, the gases being vented at 139 and the condensate flowing into and through the economizer 141. The water flows from economizer 141 through pipe 142, meter 143, and pipe 144 to the sewer, indicated at 145. It will be noted that in the heating system shown in this example, the flow-controller 5 is positioned beyond the temperature control valve 131, and the steam is utilized at a higher pressure. The flow-controller functions in substantially the same manner as described in connection with the sub-atmospheric system shown in Fig. 4, so as to avoid excessive demands on the central steam supply main when the heating system is first placed in service.

Instead of the Venturi-tube 16 here shown by way of example, other forms of restricting ori-

fices or other metering devices may be used to increase the velocity and decrease the pressure at a location in advance of the control valve 5.

Wherever it may be desirable, the condensate from the heating system, (in either example shown or in other types of systems) may be returned to the generating plant through a system of return pipes to be provided therefor.

A single centrally located flow-control or demand valve might be used instead of a plurality of valves, one for each system or branch. It is preferable, however, to use a separate valve for each system thus insuring better regulation and greater flexibility of operation.

It should be noted that the use of this flow-controller not only increases the converted load that may be carried by the central heating station and main conduit, but also provides for more economical operation of the central heating station. A boiler plant operates most efficiently when carrying a substantially constant normal maximum twenty-four hour load. Since the boiler-plant must be designed to carry the maximum peak-load it will operate for a greater portion of the time at considerable less than normal capacity, thus not only increasing the initial cost but decreasing the efficiency of its normal operation. With the use of these improved demand-control valves, a boiler plant of less capacity and hence less initial cost is required and furthermore this plant will be operated under more economical conditions for the greater portion of the time, that is will more nearly carry its most efficient maximum load.

I claim:

1. The method of increasing the connected load carrying capacity of a central steam supply distributing main from which a plurality of separate heating systems are supplied with steam, which consists in restricting the rate of steam flow from the main to one of the systems to a maximum substantially corresponding to the normal maximum demands of that system after the heating apparatus and building heated thereby have been raised to the normal temperature.

2. The method of increasing the connected load carrying capacity of a central steam supply distributing main from which a plurality of separate heating systems are supplied with steam, which consists in limiting the maximum rate of steam flow from the main to one of the systems in response to pressure differences resulting from variations in the rate of steam flow to that system.

3. The method of supplying steam to a plurality of separate steam heating systems, which consists in generating the steam at a single common source, transmitting this steam through a main conduit having branches leading to the several individual systems, and restricting the flow of steam to one of the systems to a predetermined maximum substantially corresponding to the normal maximum demands of that system after the materials heated by that system have been raised to the normal desired temperature.

4. The method of supplying steam to a plurality of separate steam heating systems, which consists in generating the steam at a single common source, transmitting this steam through a main conduit having branches leading to the several individual systems, and restricting the flow of steam to a system to a predetermined maximum in response to pressure differences resulting from variations in the rate of steam flow to the system.

5. The method of increasing the connected load carrying capacity of a central steam supply distributing main from which a plurality of separate heating systems are supplied with steam, which consists in restricting the rate of steam flow from the main to each of the systems to a maximum substantially corresponding to the normal maximum demand of that system after the heating apparatus and building heated thereby have been raised to the normal temperature.

6. The method of increasing the connected load carrying capacity of a central steam supply distributing main from which a plurality of separate heating systems are supplied with steam, which consists in limiting the maximum rate of steam flow from the main to each system in response to pressure differences resulting from variations in the rate of steam flow to the system.

7. The method of supplying steam to a plurality of separate steam heating systems, which consists in generating the steam at a single common source, transmitting this steam through a main conduit having branches leading to the several individual systems, and restricting the flow of steam to each of the systems to a predetermined maximum substantially corresponding to the normal maximum demands of that system after the materials heated by that system have been raised to the normal desired temperature.

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