June 2, 1959 C. D. MacCRACKEN ET AL 2,889,116

HOT WATER HEATING SYSTEMS

Filed May 18, 1953 2 Sheets-Sheet 1

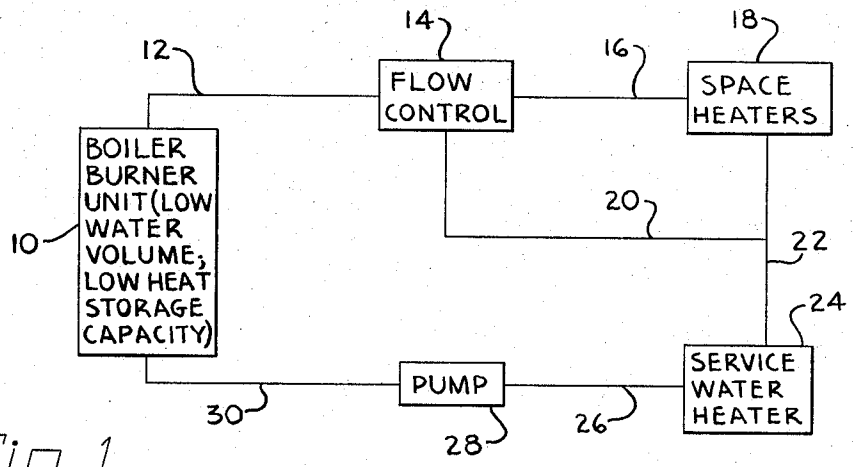

Fig. 1.

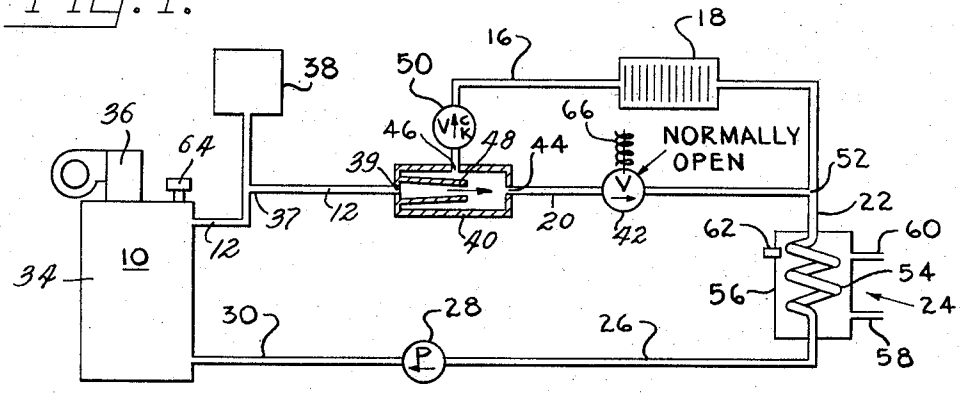

Fig. 3.

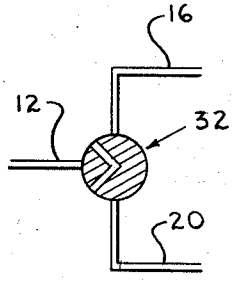

Fig. 2.

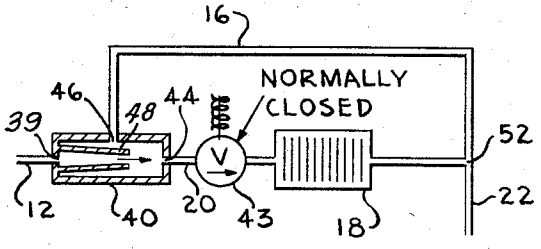

Fig. 3a.

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Filed May 18, 1953 2 Sheets-Sheet 2

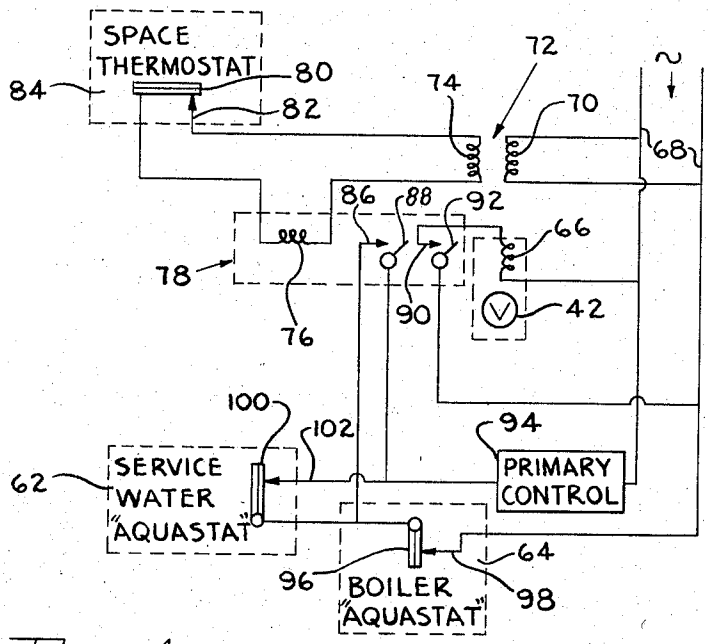

Fig. 4.

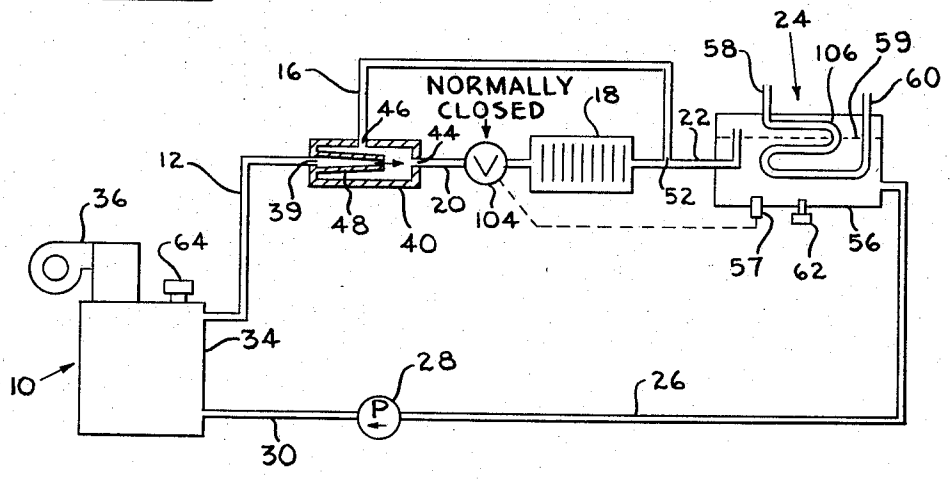

Fig. 5.

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2,889,116

HOT WATER HEATING SYSTEMS

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Application May 18, 1953, Serial No. 355,602

13 Claims. (Cl. 237—8)

This invention relates to improvements in heating systems, and particularly to an improved heating system of the hot water type for both space heating and service water heating.

At one time, it was common practice to circulate the heating medium through the various components of a hot water heating system solely by thermogravitational action. However, with the advent of intermittently fired burners both for warm air and for hot water heating systems, the hot water system with thermogravitational circulation was at a competitive disadvantage because of its slower "pickup" or response to a demand for heat. This led to the adoption of circulating pumps in hot water systems for speeding up the distribution of heated water to the space heating elements (e.g., radiators, convectors, etc.), although it is still common practice to supply hot liquid by thermogravitation to the service water heater in systems supplying both space and service water heat.

Forced circulation alone, however, does not give an entirely satisfactory solution to the problem. In the usual case, a demand for space heat will come after the heating system has been quiescent for a time, so that the temperature of the water in the space heating elements will be at or near room temperature. Therefore, in order to have fast pickup, there should be somewhere in the system a reserve supply of hot water that can be circulated promptly to the space heaters, because the conventional boiler will not pass heat to the liquid rapidly enough to raise the system liquid temperature instantaneously.

In a majority of hot water heating systems, the boiler comprises one or more thick-walled cast iron or steel sections of considerable water capacity and considerable heat storage capacity. In such systems, it is the water in the boiler that is relied on as the hot reserve supply that will be available for quick pickup when there is a demand for space heat. However, as is well known, draft-induced air flow through the combustion space and flue gas passages of a boiler when the burner is not operating has a definite cooling effect on the boiler and the water contained therein. This so-called "stand-by loss" is quite substantial, and if the intervals between firings of the boiler are of any appreciable duration, practically all of the reserve heat in the boiler water and the boiler walls will be dissipated between calls for heat. This, of course, will result in a marked lag in the space heating pickup, regardless of the fact that forced circulation is used, because the boiler walls and the water in the boiler both must be reheated before any heat will be delivered to the space heaters.

In short, the only reliable method of avoiding pickup lag in systems of the foregoing type is to arrange the system controls so that the burner will operate as often as needed to maintain the boiler water at the required temperature. This is a wasteful expedient, since the boiler must be fired regularly to make up constantly for the stand-by losses, even though there is little demand for space heat.

It is, accordingly, among the objects of the present invention to provide an improved hot water heating system which will respond rapidly to a demand for space heat, and yet which will have very low stand-by losses and consequent economy of operation.

Another object of the invention is to provide a hot water system, both for space heating and for service water heating, that will insure an adequate supply of hot service water at all times, that will have minimum response time when space heat is called for, that will have negligible stand-by losses, and in which the space heaters are by-passed by means of simple, inexpensive elements when no space heat is required.

In accordance with a preferred embodiment of the invention, the foregoing and other related objects and advantages are attained in a system wherein heated water is force-circulated from a boiler of very small water capacity and negligible heat storage capacity through serially connected space heating and service water heating elements. By having a boiler of very low water-and-heat storage capacity, the stand-by losses are kept at a minimum. A valving and by-pass arrangement paralleling the space heating element or elements allows the system to force-circulate hot water solely through the service water heater when space heat is not needed, to maintain the service water temperature. Then, when space heat is called for, quick pickup is assured by the reserve supply of heated water that is maintained in the service water heater. Since the service water heater can be insulated readily to store heat much more efficiently than a boiler subject to stand-by "draft cooling," it is seen that the quick pickup requirement is simply satisfied and at a minimum of operational expense.

A more complete understanding of the invention, and of further objects and features thereof, can be had by reference to the following description of illustrative embodiments thereof, when considered in connection with the accompanying drawing, wherein:

Figure 1 is a block diagram showing the general arrangement of the elements in a system embodying the invention,

Figure 2 illustrates a three-way valve suitable for use in the system of Figure 1,

Figures 3 and 3*a* are schematic diagrams, showing in more specific detail the arrangement of elements in a system embodying the invention.

Figure 4 is a circuit diagram, showing an electric control circuit for the system of Figure 3, and

Figure 5 is a schematic diagram showing an alternative arrangement of elements in a system embodying the invention.

Referring to Figure 1 of the drawing, the elements of a hot water heating system embodying the present invention include a boiler-burner unit **10**, preferably having a boiler of small water-containing volume and relatively low heat storage capacity. A particularly suitable boiler-burner unit for a system of the type being described is disclosed and claimed in Patent No. 2,773,488 of MacCracken et al., issued December 11, 1956 and assigned to the assignee of the present application. Briefly, the boiler element in the unit described in detail in the foregoing patent comprises a "quilted surface" shell formed of thin superposed metal sheets. The superposed sheets are sealed together along the edges and at spaced points therebetween, and separated except where sealed to provide a water jacket of relatively small water-containing volume and low heat storage capacity. It will, of course, be understood that the present invention is not limited to this specific type of boiler element, and that the system described herein can be used to advantage with many different types of boilers and boiler-burner units.

An outlet line **12** leads from the boiler unit **10** to flow control means **14**, specific examples of which are given

hereinafter. One line 16 from the flow control 14 leads to one or more space heating elements 18, such as radiators, convectors, radiant panels, or the like. A second line 20 from the control 14 by-passes the space heaters 18 and connects on the down-stream side of the heaters to a connecting line 22 which leads to a service water heater 24. As is explained more fully hereinafter, the heater 24 may be either of the "storage" type, wherein boiler water is circulated through a coil in a hot water storage tank, or of the "tankless" type, wherein the boiler water circulates through a tank which contains a coil for conducting service water. In either event, the service water will comprise two water-conducting elements in heat exchanging relation, and one of these elements preferably will comprise a tank having a substantial water storage capacity, say, of the order of 20 gallons or more. From the service water heater 24, a line 26 leads to a circulating pump 28 which is connected to a boiler inlet line 30.

It will be seen from the foregoing that the space heaters 18, the service water heater 24, and the pump 28 all are connected in a series liquid circuit between the boiler outlet and inlet lines 12 and 30, with a by-pass line 20 paralleling the space heater 18. The control 14 and coupling lines 16, 20 are so arranged that the boiler water can be circulated either through or around the space heaters 18, as required. However, the service water heater 24 will always be in the circuit.

In operation, if heat is required either by the space being heated or by the service water heater, a suitable electric circuit will function to energize the boiler-burner unit for heating the boiler water. Simultaneously, the pump 28 will be energized to force circulation through the circuit. If the space to be heated is calling for heat, the control 14 can be arranged to direct the boiler water to circluate through the line 16, through the space heaters 18, through the line 22 and thence through the service water heater 24. If, on the other hand, heat is required only for the service water heater 24, then the control 14 can be set to divert the entire flow through the service water heater. In either case, however, it is seen that the water is force-circulated through the service water heater. The advantage of this is two-fold. First, a supply of hot service water is assured at all times, with quick recovery after a prolonged draw. Second, the heater 24 serves as a reservoir of heated liquid which is always available for quick pickup when the system is being asked to supply space heat. Therefore, even though the space heating portion of the system may have been quiescent for a considerable period of time, there will always be a reserve supply of hot liquid to give a quick space heat response when space heat is called for. At the same time, the stand-by losses from the storage heater and from the low heat-and-water storing boiler will be quite negligible.

The flow control 14 may take any one of a number of different forms. For example, a three-way valve 32, may be used at the junction of the outlet line 12 and the distribution lines 16, 20, as shown in Figure 2. Such a valve can be operated either manually or by a system of automatic controls to direct the system circulation either through the line 16 to the space heaters, or through the line 20 around the space heaters, depending on the heating requirements at any given time. However, a manual control ordinarily will be objectionable, as it will require recurrent attention, while an automatic control system for a valve of the type shown in Figure 2 will be relatively complex. Examples of very simple (and, hence, preferable) automatic flow control means, wherein the flow is primarily controlled by temperature responsive elements, are described in connection with other system details given hereinafter.

In hot water heating systems heretofore proposed wherein the boiler water is force-circulated either through the space heaters or the service water heaters, it has been customary, and, in fact, rather essential, to give the service water heater priority of demand on the system output in order to insure an adequate supply of hot service water at all times. Otherwise, during a prolonged space heat demand, the hot service water supply might be completely exhausted and could not be replenished until the space heat demand was satisfied. On the other hand, this can well entail a substantial delay in supplying space heat, where calls for both space and service water heat occur simultaneously. This is particularly true where there is a prolnoged demand for hot service water. In the system of the present invention, there is no such limitation on the choice of demand priority. By circulating the boiler water through the space heaters and the service water heater in series, either space heat demands or service water heat can be given nominal priority without seriously effecting the supply of the "secondary" demand.

With the so-called tankless type service water heater, there is a theoretical advantage in giving the service water heater demand priority, which simply means arranging the controls so that the temperature of the service heater tank must be above a preset minimum before any space heat will be delivered. With the storage tank type of heater, there is no reason to prefer the service heater, and space heat can be given priority. In either case, however, within a comparatively short time after space heating begins, the temperature of the system liquid will be high enough so that both services can be handled simultaneously. Therefore, the question of service heat priority vs. space heat priority in the system of the present invention is not nearly as critical as it is in a system where only one demand can be handled at any given time.

Consider, for example, the system shown in Figure 3. This system is seen to include a boiler-burner unit 10, comprising a boiler 34 carrying a top-mounted burner 36 as described in the above-mentioned patent of MacCracken et al. At a T 37, the boiler outlet line 12 is connected to an expansion tank 38 and to the inlet port 39 of a Venturi fitting 40. The Venturi fitting 40 is cooperable with a solenoid actuated valve 42 in a by-pass line 20 to control the direction of flow of the boiler water.

The Venturi fitting 40 comprises a hollow casting having an inlet port 39, a first outlet port 44 opposite the inlet port 39, and a side outlet port 46. A tapered nozzle 48 extends from the inlet port 39 to a point somewhat beyond the second or side outlet port 46. The by-pass line 20 is connected to the first outlet port 44, while a line 16 extends from the second outlet port 46 through a check valve 50 to a space heater 18, schematically represented as a radiator. The by-pass line 20 extends through the valve 42 to a T 52 in the radiator outlet line 22.

From the T 52, the line 22 connects to a coil 54 in the tank 56 of a service water heater 24. From the coil 54, a line 26 leads through a circulating pump 28 to the boiler inlet line 30. Inlet and outlet lines 58, 60 are provided for coupling the tank 56 to the usual water supply system and outlet faucets (not shown). The system of Figure 3 also includes an Aquastat element 62 extending into the tank 56 to sense the tank water temperature, and a similar Aquastat element 64 for sensing the water temperature in the boiler.

In the Figure 3 system, the valve 42 is arranged to be actuated by a solenoid 66 that is connected in the electrical control circuit for the system, which circuit will now be described.

Referring to Figure 4, there is shown an electrical circuit comprising power supply lines 68 leading in from the usual alternating voltage supply source (not shown). Connected across the lines 68 is the primary winding 70 of a step-down transformer 72. The transformer secondary 74 is connected through the operating winding 76 of a relay 78 to the contacts 80, 82 of a thermostat element 84.

The thermostat 84 will be located at a suitable point in the space to be heated, and may comprise any one of a variety of temperature-responsive switching devices well known in the art. For simplicity, one of the thermostat contacts 80 is shown as a bimetallic member that will bend in response to variations in the temperature of the space in which the thermostat is located to make or break a circuit through the other contact 82.

The relay 78 has two sets of contacts, 86, 88, and 90, 92. One set of contacts, 90, 92, is connected to the supply lines 68 in series with the solenoid 66 that actuates the valve 42. The other set of relay contacts 86, 88 is connected in series with the contacts 96, 98 of the boiler Aquastat 64 to make or break a circuit from the lines 68 through a so-called "primary control element" 94. A second set of contacts for completing a similar circuit through the primary control 94 and the Aquastat 64 comprises the contacts 100, 102 of the service water heater Aquastat 62. Both aquastats are shown schematically as having a temperature sensitive bimetal contact element (96 and 100).

For simplicity, the details of the primary control 94 are not shown, as such controls are well known in the art. Suffice it to say that when a circuit from the power supply 68 is completed through the primary control, the burner 36 and the pump 28 in the Figure 3 system will be energized. Since the boiler Aquastat contacts 96, 98 normally will be closed, and will open only if the boiler water temperature goes above a safe upper limit, the supply of power to the primary control 94 will depend mainly on the position of the relay contacts 86, 88 or the service water Aquastat contacts 100, 102.

The system operation can be seen to depend on the heat requirements of the space to be heated and of the service water heater. If, for example, heat is required by the service water heater but not by the space to be heated, the contacts 100, 102 will close, completing the circuit to the primary control 94 and thereby energizing the burner 36 and the pump 28. Under these conditions, the thermostat contacts 80, 82 will be open, leaving the relay 78 de-energized. Hence, the valve-actuating solenoid 66 will receive no energizing current, and the valve 42 will remain open. This will allow the liquid flowing through the Venturi fitting 40 to pass through the by-pass line 20, and all of the system heat will go to the tank 56 through the medium of the heat exchange coil 54. As long as the valve 42 is open, the action of the Venturi element 40 will prevent any of the system liquid from circulating through the space heater line 16. In fact, there will be a slight suction or pressure drop at the side outlet port 46 as the water flows through the nozzle 48 and out of the port 44. Under these conditions, it would be possible for small amounts of hot liquid to flow "backward" through the space heater 18 from the T 52 to the Venturi port 46. To preclude the possibility of this reverse flow when no space heat is required, it is preferable to include the check valve 50 in the space heater line 16, as shown.

When space heat is required, the thermostat contacts 80, 82 will close, completing a circuit through the relay winding 76 and thereby closing the contacts 86, 88 and 90, 92.

This will complete the circuit of the primary control to energize the pump and burner, and also will energize the solenoid 66 to close the valve 42. Now the hot water from the boiler will be diverted through the side port 46 of the Venturi 40 to flow through the space heaters 18. However, the system liquid will continue to flow through the service heater coil 54 in series with the space heater 18. Since the tank 56 normally will be filled with hot water at all times, rapid pickup in space heat will be insured by the heat exchange between the hot service water and the circulating system liquid. During a given firing cycle, the temperature drop across the space heaters will increase while the temperature rise across the boiler remains constant and the boiler outlet temperature rises. Initially, of course, the service heater tank temperature will drop somewhat when the room temperature radiator water begins circulating through the heater tank coil and picks up heat from the hot service water. However, until the water temperature at the boiler outlet reaches a maximum, the temperature drop across the space heaters will be less than the temperature rise across the boiler, so that the circulating liquid temperature at the inlet to the service water heater will rise fairly quickly to a value at which the water in the tank 56 will no longer be losing heat. Meanwhile, a fairly limited demand for hot service water ordinarily can be met, if required, because there will be a temperature drop across the service tank from top to bottom, rather than a uniform decrease in the entire tank liquid temperature. This will leave a supply of hot water near the top of the service tank for filling a reasonable demand. Within a fairly short time, the temperature of the water leaving the radiators will be high enough to reverse the direction of heat exchange in the heater tank 56, and the temperature in the latter will begin to rise again. Thereafter, the system will rapidly regain balance throughout. When the system has been operating long enough for the boiler outlet temperature to be at or near maximum, enough heat can be supplied to the service heater tank to maintain the temperature of the service water fairly well, even though service water is being drawn at the time.

For example, in a typical case, the system might be designed for a 20° temperature rise across the boiler, a 20° drop across the space heaters at a maximum boiler outlet temperature of 200°, and a minimum service water tank temperature of 140°. With such an arrangement it is seen that for any boiler outlet temperature above, say, 158°–160° F., the service heater tank temperature will begin to go above the design minimum of 140° F., and may even go as high as 180° F.

Obviously, there are a great many possible combinations of demand conditions that can occur in a typical system installation, each of which will cause a slightly different system reaction. At one extreme, there is the possibility that a demand for space heat will occur during or just after a prolonged draw of service water, in which case the temperature of the liquid in the tank 56 may be too low to obtain the desired space heat "boosting" action. However, this is not considered a comparative disadvantage, since it detracts no more from the desired operating characteristics of the present system than does a similar coincidence of demands in other comparable types of heating systems. In fact, it is believed that the present system will satisfy both demands, even under the severely adverse conditions suggested above, more promptly and effectively than any comparable prior art system. Furthermore, as has just been explained, a condition will soon be reached in which both demands can be met on a continuing basis, which is not the case with any system of the type, for example, in which either space heat or service water heat can be supplied at any given time by forced circulation, but not both.

While the system shown in Figure 3 will function in an entirely satisfactory manner, it can be simplified somewhat as shown in Figure 3*a* to eliminate the check valve 50 from the Figure3 arrangement. To simplify the drawing, only part of the complete system is shown in Figure 3*a*, it being understood that the portion shown will replace that part of the Figure 3 system extending from the T 37 to the coil 54, and that the two systems otherwise are identical throughout and can be used interchangeably with the Figure 4 control circuit.

In the system illustrated in Figure 3*a*, the space heating element 18 is placed in the line 20 that extends from the first Venturi outlet port 44, in series with a normally closed, solenoid actuated valve 43, rather than in the line 16 that extends from the side Venturi outlet 46. With this

arrangement, as long as there is no demand for space heat, the valve **43** will divert the liquid flow through the by-pass line **16**. When space heat is called for, the control circuit of Figure 4 will function to open the valve **43**, allowing the heated boiler water to pass through the space heater **18**. If there should be some reverse flow through the line **16** under these conditions due to the action of the Venturi **40**, it will be of little consequence.

In Figure 5 there is shown an alternative embodiment of the invention, wherein both the expansion tank **38** and the check valve **50** in the space heater line **16** in the Figure 3 system have been eliminated.

Referring to Figure 5, there is shown a boiler-burner unit **10**, corresponding to the unit **10** shown in Figure 3, with an outlet line **12** leading to the inlet **39** of a Venturi fitting **40**. The first outlet port **44** of the fitting **40** is coupled to a line **20** leading to a space heater **18** through a valve **104**, while the second Venturi outlet port **46** is coupled to a by-pass line **16** leading to a T **52** on the downstream side of the space heater **18**. From the T **52**, the line **22** opens into the tank **56** of a service water heater **24**. Inside the tank **56**, a coil **106** is provided through which to circulate service water to be heated. Inlet and outlet lines **58**, **60** are provided for the coil **106**, to connect to the usual service water supply and faucets (not shown). With this so-called tankless type heater, there may also be included a tempering or mixing valve (not shown) on the outlet line **60** for mixing the heated service water with cooler water to maintain a more uniform supply temperature.

Extending into the tank **56** is a temperature responsive element **57** for mechanically actuating the valve **104**. The mechanical details of the element **57** and the linkage to the valve **104** can take any one of a number of well known forms. A typical arrangement of such a valve control is shown, for example, in U.S. Patent No. 2,322,-872 to Moore.

From the tank **56**, a line **26** leads through a circulating pump **28** back to the boiler inlet line **30**.

It will be understood that the system of Figure 5 also will include an electrical control circuit generally similar to that shown in Figure 4, connecting the Aquastats **62**, **64** and a thermostat (not shown) located in the space to be heated, to control the operation of the burner and the pump, although, of course, such circuit will not include the solenoid **66** of Figure 4. In the Figure 5 system, when either the service water temperature or the temperature in the space to be heated falls below a preselected minimum value, the burner **36** and pump **28** will be energized to heat and circulate the water in the system. If the boiler water temperature exceeds a safe maximum value, the Aquastat **64** will act to shut off the burner and pump.

One of the differences between the systems shown in Figures 3 and 5 is that in the service water heater **24** in Figure 5 service water is circulated through a stored body of heated liquid, rather than storing any appreciable quantity of heated service water. While the heater **24** in Figure 5 is similar to the usual "tankless" type heater, the tank **56** has a considerably greater liquid capacity than is conventional in this type of heater. The reason for this is to provide sufficient reserve stored heat to insure quick pickup when space heat is called for.

An advantage in using the tankless type of service water heater is that the storage tank can be utilized both for heating the service water and as an expansion tank. That is, when the system is filled, the tank **56** is only partly filled, say to the level indicated by the broken line **59**. A small amount of air is trapped in the upper part of the tank to serve as a cushion to absorb the changes in system pressure that accompany changes in the temperature of the liquid in the system. This, of course, eliminates the necessity for the separate expansion tank **38** shown in the Figure 3 system.

While the Figure 5 system can be arranged either for space heating or service water heating priority, it is preferably with the tankless type heater to give the service heater first priority. With a storage type heater, as explained in connection with the Figure 3 system, an appreciable time will elapse after space heat is called for before the temperature of water at the hot water faucet will change noticeably. With the tankless heater, on the other hand, a change in the temperature of the boiler water circulating through the heater will be reflected rather quickly at the hot water faucet. Hence, if hot water is being drawn for a shower bath, for example, and the hot-cold mixture has been adjusted as desired, any appreciable change in the temperature of the water in the heater tank, such as could be expected to accompany a demand for space heat, no doubt would produce an undesirable change in the shower water temperature. Therefore, service heater demand priority is deemed preferable with the tankless type heater, simply to insure a uniform service tank temperature. On the other hand, even if the service heater is given first demand, it is still advantageous to have the space heater and service heater in series when space heat is being supplied because once the space heaters begin to warm up, as already explained, the residual heat in the water leaving the space heaters often will be sufficient to maintain the temperature in the service heater tank even though service water is being drawn at the time.

The direction of flow in the Venturi fitting **40** will depend on the setting of the valve **104** in Figure 5. This, in turn, will depend on the temperature of the liquid in the service heater tank **56**. If the temperature in the service water heater is below the pre-set minimum, the valve **104** will remain closed until the service tank temperature is high enough to actuate the thermally responsive element **57**. Thereupon, the valve **104** will be opened by the element **57**. If space heat then is called for, the flow will be through the line **20** and the space heater **18**. Since there will be an assured supply of hot liquid in the tank **56** at all times, it is seen that only hot liquid normally will flow through the space heater **18**. If the liquid in the space heater **18** is at a relatively low temperature when the system comes on, after a short interval the temperature in the service water tank **56** will drop sufficiently to close the valve **104** and divert the flow from the space heater **18** until the service tank temperature has returned to normal. Thereupon, the valve **104** again will open, allowing the heated liquid to flow through the space heater **18**. Even under the most adverse conditions, as where space heat is called for at the end of a prolonged draw of service water, heated liquid will begin to flow through the space heater at the earliest possible time that there is liquid of sufficiently high temperature available to do any appreciable heating. On the other hand, if the space heat demand comes when the tank **56** is fully heated, then the space heat demand will be met promptly, and the series flow of liquid through the space heater and the service heater soon will reach the balanced condition of heat transfer previously described.

What is claimed is:

1. In a space heating and service water heating system, a boiler for heating water to be circulated through said system and having a relatively small water containing volume and relatively low heat storage capacity, a service water heater comprising means defining first and second water heater passages through which to circulate water, said passages being arranged in said heater in heat exchanging relations to each other, a space heating element through which to circulate heated water from said boiler for space heating, water inlet and outlet lines leading to and from said boiler, a Venturi fitting having an inlet port and two outlet ports, said outlet line being connected to said inlet port, a line connecting one of said outlet ports to said space heating element, a circulating pump, a liquid circuit connecting one of said water heater passages and said pump in series between the other of said

outlet ports and said inlet line, a line connecting the downstream side of said space heating element to said circuit on the upstream side of said one water heater passage, and a valve in said system cooperable with said fitting to direct water flow in said system either through said space heating element or through the portion of said circuit connecting said other outlet port to said one water heater passage.

2. In a space heating and service water heating system, a boiler for heating water to be circulated through said system and having a relatively small water containing volume and relatively low heat storage capacity, a service water heater comprising means defining first and second water heater passages through which to circulate water, said passages being arranged in said heater in heat exchanging relation to each other, a space heating element through which to circulate heated water for space heating, water inlet and outlet lines leading to and from said boiler, a Venturi fitting having an inlet port and two outlet ports, said outlet line being connected to said inlet port, a line connecting one of said outlet ports to said space heating element, a circulating pump, a liquid circuit connecting one of said water heater passages and said pump in series between the other of said outlet ports and said inlet line, a line connecting the downstream side of said space heating element to said circuit on the upstream side of said one water heater passage, a valve in said system cooperable with said fitting to direct water flow in said system either through said space heating element or through the portion of said circuit connecting said fitting to said one water heater passage, and a temperature-responsive control element connected to said valve to control the actuation of said valve.

3. In a space heating and service water heating system, a boiler for heating water to be circulated through said system and having a relatively small water containing volume and relatively low heat storage capacity, water inlet and outlet lines leading to and from said boiler, a space heating element through which to circulate heated water for space heating, a service water heater comprising means defining a first water heater passage through which to circulate water to be heated and a second water heater passage through which to circulate heated water from said boiler, said water heater passages being arranged in said heater in heat exchanging relation to each other, a circulating pump, a liquid circuit connecting said space heating element, said second service water heater passage and said pump in series between said outlet and inlet lines, a by-pass line connected in parallel with said space heating element, and flow control means including a valve in series with said space heating element for directing water flow in said system either through said space heater or through said by-pass line.

4. In a space heating and service water heating system, a boiler for heating water to be circulated through said system and having a relatively small water containing volume and relatively low heat storage capacity, water inlet and outlet lines leading to and from said boiler, an element through which to circulate heated water for space heating, a tank through which to circulate service water to be heated and containing a coil through which to circulate heated boiler water, a circulating pump, a liquid circuit connecting said space heating element, said coil and said pump in series between said outlet and inlet lines, a by-pass line connected in parallel with said space heating element, flow control means including a normally-open solenoid-actuated valve in series with said space heating element to direct water from said boiler either through said element or through said by-pass line, and an electrical control circuit for said system including a temperature-responsive switch element responsive to the temperature of the space to be heated by said space heating element and connected in said electrical circuit to control the actuation of said valve solenoid.

5. In a space heating and service water heating system, a boiler for heating water to be circulated through said system and having a relatively small water containing volume and relatively low heat storage capacity, a tank through which to circulate water to be heated, a coil in said tank through which to circulate heated water from said boiler, an element through which to circulate heated water from said boiler for space heating, water inlet and outlet lines leading to and from said boiler, a Venturi fitting having an inlet port and two outlet ports, said outlet line being connected to said inlet port, a line connecting one of said outlet ports to said space heating element, a circulating pump, a liquid circuit connecting said coil and said pump in series between the other of said outlet ports and said inlet line, a line connecting the downstream side of said space heating element to said circuit on the upstream side of said coil, and flow control means including a valve in series with said space heating element for directing water flow in said system either through said space heating element or through the portion of said circuit connecting said coil to said other outlet port.

6. In a space heating and service water heating system, a boiler for heating water to be circulated through said system and having a relatively small water containing volume and relatively low heat storage capacity, a tank through which to circulate heated water from said boiler for heating service water and containing a coil through which to circulate said service water, an element through which to circulate heated water from said boiler for space heating, water inlet and outlet lines leading to and from said boiler, a Venturi fitting having an inlet port and two outlet ports, said outlet line being connected to said inlet port, a line connecting one of said outlet ports to said space heating element, a circulating pump, a liquid circuit connecting said tank and said pump in series between the other of said outlet ports and said inlet line, a line connecting the downstream side of said space heating element to said circuit on the upstream side of said tank, and flow control means including a valve in series with said space heating element for directing water flow in said system either through said space heating element or through the portion of said circuit connecting said other outlet port to said tank.

7. In a space heating and service water heating system, a boiler for heating water to be circulated through said system and having a relatively small water containing volume and relatively low heat storage capacity, a tank through which to circulate water to be heated and a coil in said tank through which to circulate heated water from said boiler, an element through which to circulate heated water from said boiler for space heating, water inlet and outlet lines leading to and from said boiler, a Venturi fitting having an inlet port and two outlet ports, said outlet line being connected to said inlet port, a line connecting one of said outlet ports to said space heating element, a circulating pump, a liquid circuit connecting said coil and said pump in series between the other of said outlet ports and said inlet line, a line connecting the downstream side of said space heating element to said circuit on the upstream side of said coil, flow control means including a normally-open solenoid-actuated valve in series with said space heating element to direct water flow from said boiler either through said element or through the portion of said circuit connecting said coil to said other outlet port, and an electrical control circuit for said system including a temperature sensitive switching element responsive to the temperature of the space to be heated by said space heating element and connected to control the actuation of said valve solenoid.

8. In a space heating and service water heating system, a boiler for heating water to be circulated through said system and having a relatively small water containing volume and relatively low heat storage capacity, a tank through which to circulate heated water from said boiler for heating service water and containing a coil

through which to circulate said service water, an element through which to circulate heated water from said boiler for space heating, water inlet and outlet lines leading to and from said boiler, a Venturi fitting having an inlet port and two outlet ports, said outlet line being connected to said inlet port, a line connecting one of said outlet ports to said space heating element, a circulating pump, a liquid circuit connecting said tank and said pump in series between the other of said outlet ports and said inlet line, a line connecting the downstream side of said space heating element to said circuit on the upstream side of said tank, flow control means including a normally-open valve in series with said space heating element to direct water flow from said boiler either through said element or through the portion of said circuit connecting said tank to said other outlet port, and a temperature-responsive control element responsive to the temperature of the water in said tank and connected to said valve to control the actuation of said valve.

9. In a space heating and service water heating system, a boiler for heating water to be circulated through said system, a service water heater comprising means defining a first passage through which to circulate water to be heated and a second passage through which to circulate heated water from said boiler, said passages being arranged in said heater in heat exchanging relation to each other, a circulating pump, a space heater through which to circulate heated water from said boiler, circuit means connecting said boiler, said second passage, said pump

and said space heater in series, a by-pass circuit connected in parallel with said space heater, and flow control means in said system for directing water flow in said system either through said space heater or through said by-pass circuit.

10. The invention defined in claim 9, wherein said control means includes a valve and a temperature-responsive control element for said valve, said temperature-responsive element being disposed in said first water heater passage to respond to the temperature of the water in said first water heater passage.

11. The invention defined in claim 9, wherein said first water heater passage comprises a tank and wherein said second water heater passage comprises a coil contained within said tank.

12. The invention defined in claim 9, wherein said second water heater passage comprises a tank, and wherein said first water heater passage comprises a coil contained within said tank.

13. A system as defined in claim 9 wherein said flow control means comprises a valve in said by-pass circuit.

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