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Moseley, Jr.

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[45] **Mar. 11, 1975**

[54] **WATER HEATING SYSTEM**

[76] Inventor: **Charles D. Moseley, Jr.**, P.O. Box 449, Lynchburg, Va. 24503

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[21] Appl. No.: **323,739**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 260,667, June 7, 1972.

[52] **U.S. Cl.** **237/59**, 126/362, 137/604, 137/563, 237/63

[51] **Int. Cl.** **F24d 3/00**

[58] **Field of Search** 126/362; 137/604, 563; 237/63, 59

[56] **References Cited**

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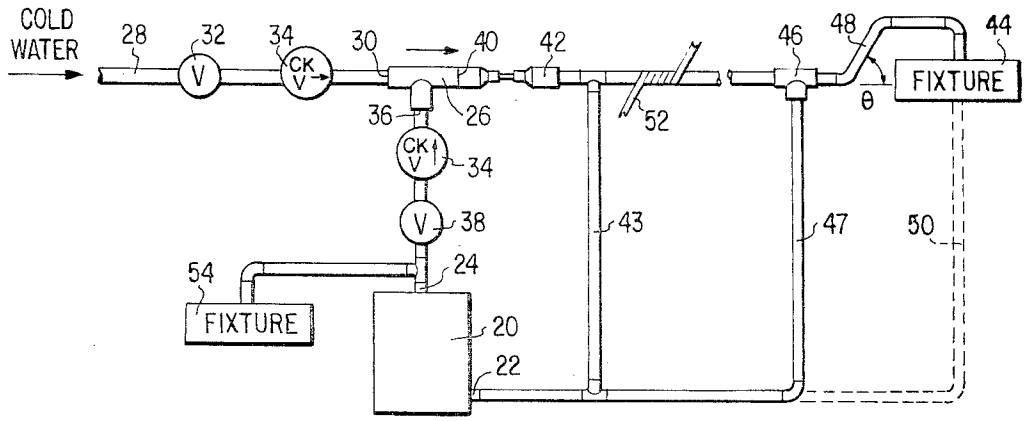
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Primary Examiner—Edward G. Favors
Attorney, Agent, or Firm—J. T. Martin; Gerald J. Ferguson, Jr.; Joseph J. Baker

[57] **ABSTRACT**

A water heating system for providing heated water at a constant temperature at all locations of intended use in either closed or non-closed loop type distribution systems. The system employs a jet entrainer as a device for mixing water supplied thereto at different temperatures and maintains the temperature of the mixed water constant regardless of variations in the pressure of the water driving the device or being entrained by the device. The jet entrainer is constructed by providing an appropriate size nozzle, tee-shaped member and mixing chamber. The nozzle is then inserted into one end of the tee-shaped member and joined thereto to form a watertight seal. The mixing chamber is then inserted into the other end of the tee-shaped member and joined thereto to form a watertight seal.

9 Claims, 11 Drawing Figures



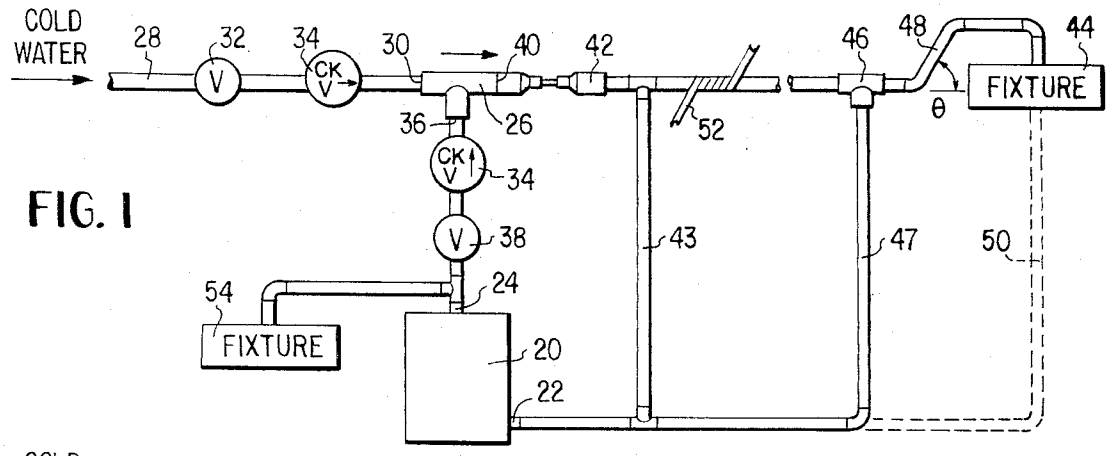


FIG. 1

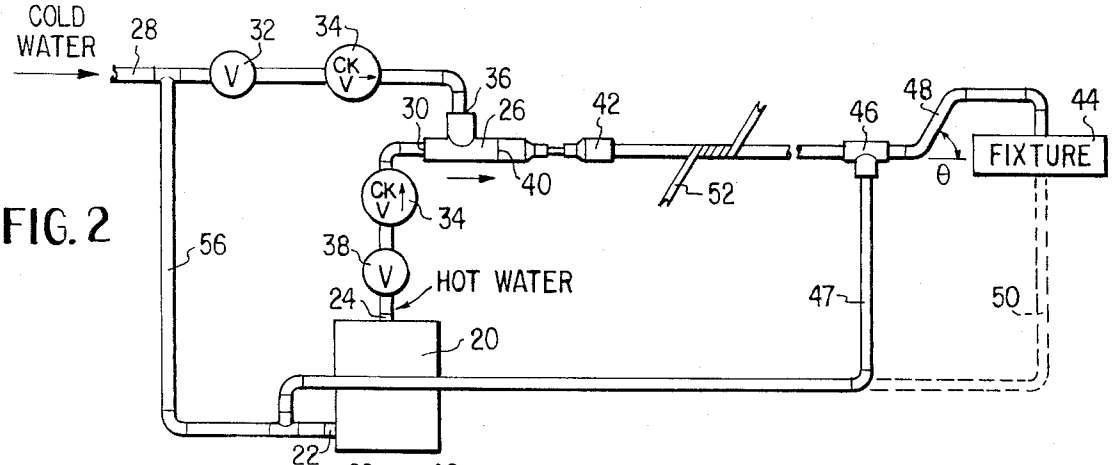


FIG. 2

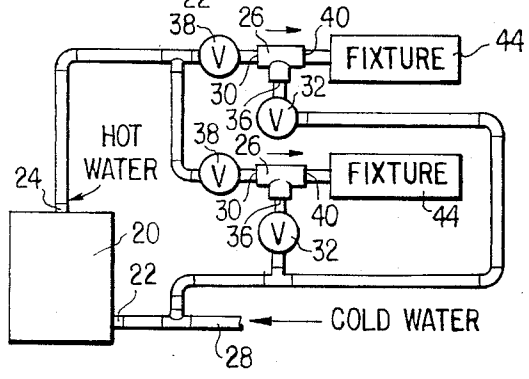


FIG. 3

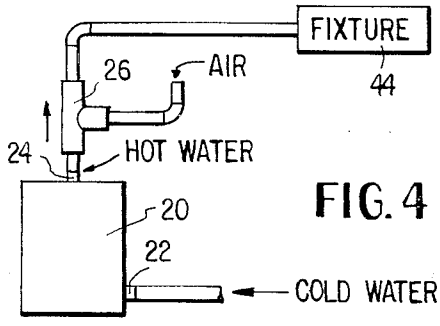


FIG. 4

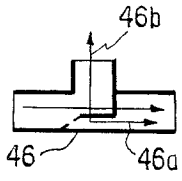


FIG. 5

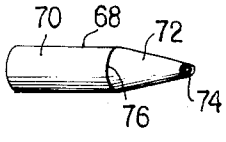


FIG. 6

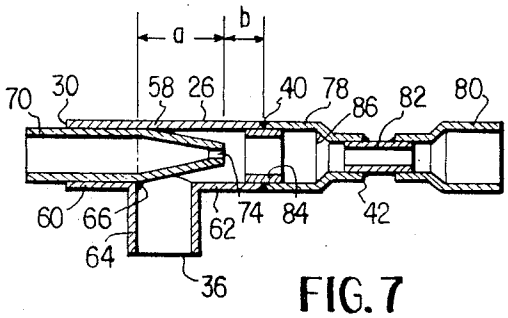


FIG. 7

FIG. 8

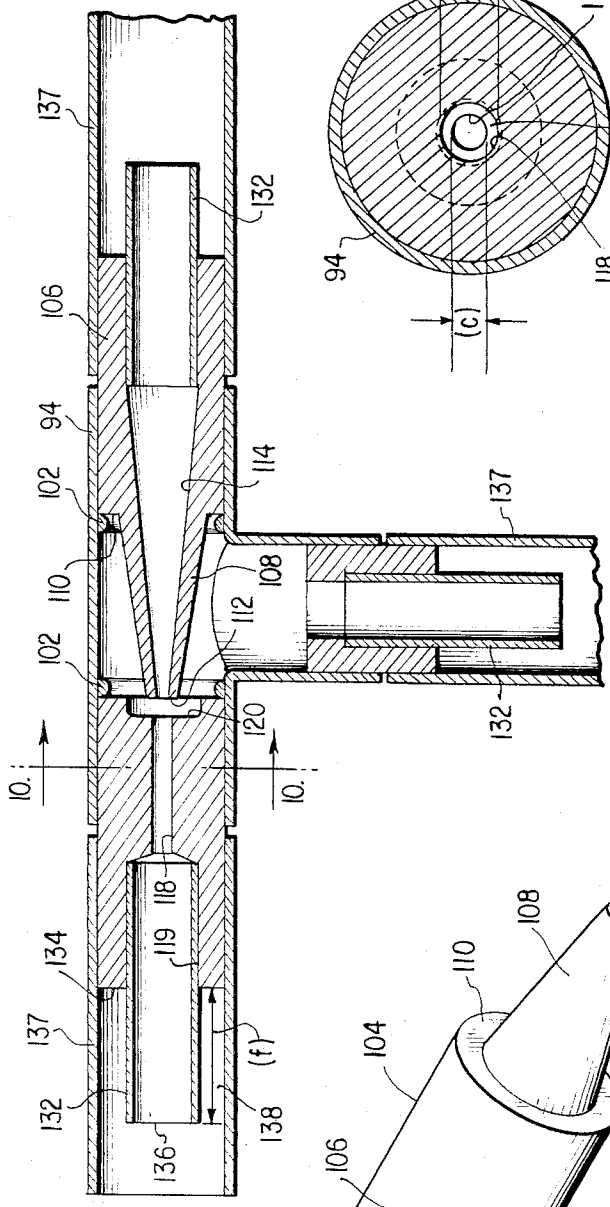


FIG. 10

FIG. 11

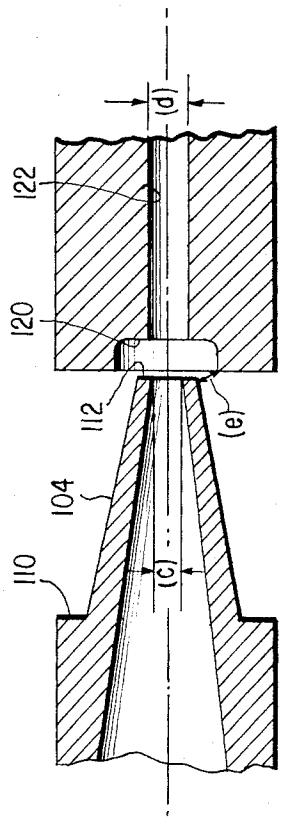


FIG. 9

WATER HEATING SYSTEM

PRIOR APPLICATION

This application is a continuation-in-part application of my application Ser. No. 260,667 filed June 7, 1972, and entitled "Improved Water Heating System Utilizing a Venturi Mixing Device and Method of Making Same."

DESCRIPTION OF THE PRIOR ART

Present day systems for supplying heated water at single or multiple temperatures are costly in their installation and maintenance and inefficient in their use. Systems which supply single temperature water be it for general washing at temperatures of about 120° F., or for sanitizing at temperatures of about 180° F., generally consist of a water heater which is supplied with city water at a temperature of about 50° F. The city water is raised to the desired temperature in the heater and then drawn off and piped to the location of intended use. As the heated water is used, additional city water is introduced into the heater and again raised to the desired temperature.

It is well known that conventional water heaters operate more efficiently if the water introduced to the heater is heated to temperatures, for example, between 150° to 200° F. Water in this temperature range is impractical for general use in the home due to the possibility of scalding the user, however, there is a need for water at these higher temperatures for use in washing machines, dishwashers and the like.

Present day dual temperature water heating systems which are capable of supplying heated water for general washing at about 100° to 120° F., and water for sanitizing at about 150° to 200° F., usually employ storage tanks, booster heaters, or tempering valves in conjunction with the water heater.

When storage tanks are used, the water is heated to about 180° F., in the water heater and a portion thereof is mixed in the storage tank with city water at about 50° F., to provide water at a temperature for general washing. This method is costly due to the added expense of the storage tank and the necessity of continuously adding heated water to the storage tank to maintain the desired temperature level. If a booster heater is used, the water is first heated to about 120° F., for general washing purposes and a portion thereof is drawn off and heated in a separate booster heater to a sanitizing temperature of about 180° F. This method is also costly and inefficient due to the added expense of the booster heater and the additional power necessary to supply both heaters.

Systems which employ tempering valves mix water from the water heater at about 180° F., with city water at about 50° F., in the valve to provide water at a temperature suitable for general washing purposes. The tempering valve has an adjustable thermostat element which senses the temperature of the mixed water to control the mixing ratio of the hot and cold water and thus the temperature of the mixed water at the setting of the thermostat element. These tempering valves have very serious disadvantages in that the thermostat elements employed therein are very slow in reacting to changes in the temperature of the mixed water due to a sudden surge or drop in the pressure or volume of either the hot or cold water being supplied to the valve which has often resulted in people being scalded or

suddenly exposed to very cold water. In addition to the foregoing disadvantages, water tempering valves presently in use are very costly to manufacture and require constant checking and maintenance to ensure proper operation.

Other devices have been tried for maintaining the temperature of the mixed water constant despite fluctuations in the pressure or volume of either the hot or cold water entering the device. These devices were tried at the location of intended use of the mixed water and not for providing a multi-temperature water heating system wherein the mixed water is maintained at a constant temperature suitable for general home use despite wide fluctuations in the pressure of the hot or cold water entering the device or in the head pressure in the system distributing the mixed water. The United States patents to Deming U.S. Pat. No. 1,498,788 (1924) and Kitchenmaster U.S. Pat. No. 3,473,567 (1969) disclose devices which employ concentric, high velocity streams of the hot and cold water which serve to mix the hot and cold water fairly well at an open fixture such as a shower head. However, such devices fail to maintain the temperature of the mixed water constant despite variations in the pressure of the water at the input connections thereto irregardless of the presence or absence of a head pressure at the output of the device as is done in the device of the present invention.

The use of the jet entrainer and mixing device of the present invention in conjunction with a conventional hot water heater can increase the output capacity of the water heater to such an extent that between 30 to 60 percent more usable hot water can be drawn from the water heater per hour for the exact same amount of fuel or electric power consumed than can be obtained from the same water heater without the device of the present invention while at the same time also providing water at sanitizing temperatures and maintaining the temperature of the usable water constant despite variations in the pressure or volume of hot or cold water entering the device or at any point in the distribution system connected to the output of the device.

Further, because water at a usable, constant temperature is always available at each location of intended use, in certain embodiments of the invention, cold water need not be mixed with hot water at such location to obtain water at a usable temperature, thus, additional savings can be realized in the amount of both hot and cold water used as well as in the sewage costs of disposing of same.

The jet entrainer and mixing device of the present invention is inexpensive to manufacture, has no moving parts to wear out or jam, is maintenance free, and can be assembled and installed by semi-skilled workmen in existing residential or commercial water heating systems.

SUMMARY OF THE INVENTION

The present invention relates to water heating systems and more particularly to a novel jet entrainer and mixing device for use therein.

The systems disclosed in the present invention are of both the closed and non-closed loop type. The closed loop system being one wherein water from the water heater is piped to the various points of intended use and returned to the water heater. The non-closed loop system being one wherein water from the water heater is

piped to various points of intended use and terminated at the last of said points.

The jet entrainer and mixing device disclosed in the present invention functions as a device for combining and mixing the hot water from the water heater and the cold water from the city supply before it is piped to the location of intended use. The jet entrainer and mixing device can also serve to provide water at specific temperatures at various remote points of the system.

The jet entrainer and mixing device comprises a nozzle, a confluent chamber and a mixing tube. The nozzle has a recess or orifice the diameter of which is slightly smaller than the diameter of the bore of the mixing tube. The orifice of the nozzle is positioned in the confluent chamber a short distance from one end of the bore of the mixing tube and the centerlines of both the orifice and the bore are coincident.

Water under pressure is fed to the nozzle thereby forming a high velocity jet stream of water which extends from the orifice into the mixing tube. The confluent chamber is filled with water under pressure which encases the water emanating from the orifice. As the water emanates from the orifice, it frictionally entrains a portion of the water surrounding it in the confluent chamber and forces it into the bore of the mixing tube where the jetted water and entrained water are mixed. If water emanating from the orifice is at one temperature and the water being entrained is at a different temperature, the temperature of the water at the output of the mixing tube will be the resultant of the two temperatures.

The jet entrainer of the present invention will maintain the temperature of the water at the output of the mixing tube constant irrespective of variations in the pressure of the water entering the nozzle or confluent chamber or variations in the head pressure exerted at the output of the mixing tube. This temperature stability results from the fact that the present jet entrainer has only one jet stream of water which entrains more or less of the water in the confluent chamber in proportion to the velocity of the jet stream or the pressure exerted on the jet stream by the water in the confluent chamber, thus, eliminating the disruptive turbulance occurring when two or more jet streams of water meet which results in no entrainment of water by either jet stream. The operation of the jet entrainer will be described in greater detail later. Various ratios of mix can be achieved between the water of the high velocity jet stream and the water being entrained by controlling the volume of water entering the nozzle and confluent chamber.

In one aspect of the present invention, the fluids being mixed are the relatively cold city water at about 50° F., which is supplied to the water heating system, the other fluid being the hot water fed from the output of the water heater which is normally in the 150° to 180° F., temperature range. Thus, by varying the volume of the hot and cold water entering the jet entrainer and mixing device, the temperature of the water at the output can be regulated. Correspondingly, water at various higher temperatures can be mixed to achieve water at a desired temperature at various remote points of the system.

The jet entrainer and mixing device of the present invention can be constructed of commercially available elements assembled in the manner disclosed herein. The two basic elements of the jet entrainer comprise a nozzle and hollow tee-shaped pipe fitting forming a confluent chamber into which the nozzle is inserted and joined to the fitting by means of solder, glue or the like depending on the material of which the elements are made. The nozzle is inserted into one of the cross-portions of the tee-shaped fitting to a position adjacent to the inner end of the stem portion of the tee-shped fitting. The mixing device is positioned in the other cross-portion of the tee-shaped fitting. Assembling the jet entrainer and mixing device and installing it in new or existing water heating system in the manner disclosed in the present application can be done by plumbers or semi-skilled workmen using ordinary tools.

When constructed and installed in the manner disclosed herein, the jet entrainer and mixing device will provide 30 to 60 percent more hot water at a specific usable temperature for distribution and use throughout an open loop system for the same fuel or electric power consumed to heat the water than conventional systems for supplying water at the same temperature. If the jet entrainer and mixing device is installed in a closed loop system or one having feedback, additional monetary savings can be realized in the amount of fuel or electric power consumed.

An additional feature of the jet entrainer of the present invention resides in its ability to dampen surge pressures or stop the phenomenon more commonly known as "water hammer" developed upon the closure of fixtures anywhere in the system.

Other and further objects and advantages of the invention will become apparent to those skilled in the art from a consideration of the following specification when read in conjunction with the annexed drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of a typical piping arrangement employing the jet entrainer and mixing device for the present invention.

FIG. **2** is a schematic representation of a variation of the piping arrangement shown in FIG. **1.**

FIG. **3** is a schematic representation of a plurality of fixtures each employing the jet entrainer and mixing device of the present invention.

FIG. **4** is a schematic representation of another embodiment of the present invention.

FIG. **5** is a cross-sectional view of a mono-flow valve.

FIG. **6** is a pictorial representation of the nozzle used in the jet entrainer of the present invention.

FIG. **7** is a cross-sectional view of the assembled jet entrainer and mixing chamber of the present invention.

FIG. **8** is a cross-sectional view of another embodiment of the jet entrainer, mixing chamber and water hammer suppressor of the present invention.

FIG. **9** is a pictorial representation of the nozzle used in the jet entrainer shown in FIG. **8.**

FIG. **10** is an enlarged cross-sectional view of the jet entrainer and mixing chamber of FIG. **8** taken along the lines **10—10.**

FIG. **11** is an enlarged view of the nozzle and mixing chamber shown in FIG. **8.**

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIGS. **1** through **4,** where the same reference numerals indicate the same parts, a conventional storage type hot water heater is indicated by numeral **20.** The hot water heater **20** is capable of raising the temperature of water introduced thereto to any

temperature up to sanitizing temperatures of between 150° to 200° F. The hot water heater **20** has an inlet **22** for introducing the water to be heated and may, in the present invention, be either city water at approximately 50° F., water that has previously been heated and mixed with the city water, or water that has been previously heated and not mixed with the city water. The water heater **20** also has an outlet **24** for supplying the heater water to the distribution system for utilization. To heat the water in the water heater **20**, a thermostatically controlled gas burner, electric heating element or other heating means (not shown) can be used. Numeral **26** indicates the novel jet entrainer of the present invention which will be described in greater detail later together with the method for its construction. The jet entrainer **26** acts to entrain hot water from the water heater **20** or cold water from the city supply depending on its mode of connection to provide water of a desired predetermined temperature at the output thereof, which temperature remains constant regardless of changes in the pressure of the hot or cold water being introduced to the system or changes in head pressure resulting from utilization of the mixed water in the system.

FIG. **1** discloses an embodiment of a system of the present invention wherein cold water under pressure is introduced to the system at cold water inlet pipe **28**, which is connected to the nozzle inlet **30** of the jet entrainer **26** via a cold water balancing valve **32** and a one-way check valve **34**. The arrow above the jet entrainer **26** indicates the direction of flow of the water through the entrainer. The balancing valve **32** is a conventional needle-type valve wherein the amount of fluid flowing therethrough is capable of being closely adjusted. The outlet **24** of the water heater **20** is connected to the inlet **36** of the jet entrainer **26** via a hot water balancing valve **38** and a check valve **34** for supplying hot water under pressure to the jet entrainer **26**. The hot water balancing valve **38** is identical in construction to the cold water balancing valve **32**. The balancing valves **32, 38** function to more accurately control the volume of hot and cold water entering the jet entrainer **26** to thereby control temperature of the mixed water at the outlet **40** of the jet entrainer **26**. For example, if the balancing valves **32, 38** are open the same amount and if the jet entrainer **26** is designed to have a one-to-one mixing ratio, that is, for each part of cold water being introduced at nozzle inlet **30**, one part of hot water from inlet **36** is entrained by the action of the jet entrainer **26** and the water at the outlet **40** will be **50** percent hot and **50** percent cold. Thus, if the combining ratio of the jet entrainer **26** is one-to-one as aforesaid and the temperature of the cold water being introduced at nozzle inlet **30** is 50° F., and the temperature being introduced at the suction inlet **36** is 180° F., then the temperature of the water at the outlet **40** will be 115° F. (50° F. + 180° F./2 = 115° F.). If it is desired to increase the temperature of the water at the outlet **40** from 115° F., to say, for example, 120° F., without changing the combining ratio of the jet entrainer **26** itself, the combining ratio can be changed by adjusting the amount of water flowing through the balancing valves **32, 38** until a temperature of 120° F., at the outlet **40** is achieved.

The outlet **40** is connected to a mixing chamber **42** which will be described in greater detail later. The mixing chamber **42** serves to thoroughly mix the water which has already been mixed to a certain extent by the jet entrainer **26**.

The mixing chamber **42** is connected to the inlet **22** of the water heater **20** and also to one or more fixtures **44** at the location of intended use. By connecting the output of the mixing chamber **42** to the input **22** of the water heater via pipe **42**, the water heater is supplied with water that has already been heated to an amount, thus, substantially reducing the time and fuel required by the water heater **20** to raise the temperature of the city water to the temperature at which the water heater is set. The hot water system as shown in FIG. **1** is an open-loop system in that hot water from the mixing chamber **42** is supplied directly to one or more fixtures **44** and no return from these fixtures **44** to the water heater **20** is provided to permit the normal circulation of the hot water through the system as occurs in closed-loop systems which have such a return (see phantom lines **50**).

In order to achieve the aforementioned circulation of hot water in the open-loop system of FIG. **1** from the fixture **44** back to the inlet **22** of the water heater **20** when the fixture **44** is located above the level of the water heater **20**, the pipe **48**, which extends above the level of the water heater **20** in the vertical direction to the fixture **44**, is slanted an angle with respect to the horizontal and a conventional mono-flow device **46** is placed between the outlet **42** and the point where the pipe **48** begins its vertical assent. The mono-flow device **46** is also connected to the inlet **22** of the water heater **20**. The mono-flow device is shown in FIG. **5** and they are commercially available from the Bell and Gossett Corporation. The mono-flow deivce **46** and the angle of pipe **48** function to permit hot water from the mixing chamber **42** to circulate up to the fixture **44** and as the hot water cools, to return the cool water back to the mono-flow device **46** and from there to inlet **22** of the water heater **20** via pipe **47**. This circulation in pipe **48** is possible because of the stratification of hot and cold water which occurs naturally when both are placed in the same container and the circulation is aided by slanting the pipe **48** and the functioning of the mono-flow device **46**. The mono-flow device **46** permits hot water shown by arrow **46*a*** to pass through the device and the cooler return water to pass back to and through the device as shown by the arrow **46*b*** in FIG. **5**.

If a closed-loop system were desired in FIG. **1**, the mono-flow device **46** and its connection **47** to inlet **22** of the water heater **20** would be eliminated as would be the necessity of slanting the pipe **48**. The fixture **44** would then be connected directly to the inlet **22** of water heater **20** as shown by phantom lines **50**. In order to further maintain the temperature of the hot water throughout the entire system, insulation **52** is wrapped around all of the pipings and fittings. Additional fixtures **54** can be connected directly to the outlet **24** of water heater **20** in the event that water at that high temperature is desired for dishwashers, clothswashers, and the like. As hot water is drawn out of the system at fixture **44** or **54**, hot water from water heater **20** will be continuously entrained by the cold water in the jet entrainer **26** and mixed in mixing chamber **42**. A portion of this mixed water will be returned to the water heater **20** to replace that being drawn off and the remainder of the mixed water will be drawn off at fixture **44**.

Referring now to FIG. 2, another embodiment of a system of the present invention is disclosed wherein cold water is supplied to the cold water inlet 28, which in turn is supplied to the inlet 22 of the water heater 20. Cold water is also supplied from the cold water inlet 28 to inlet 36 of the jet entrainer 26 via a cold water balancing valve 32 and a one-way check valve 34. The hot water outlet 24 of water heater 20 is connected to the nozzle inlet 30 of the jet entrainer 26 via hot water balancing valves 32 and 38, respectively, which function in the same manner as those described with reference to FIG. 1 as does the mono-flow device 46 and slanted pipe 48 for an open loop system. If a closed loop system is employed in the embodiment of FIG. 2, the mono-flow device 46 and its connection 47 to inlet 22 of the water heater would be eliminated as would be the necessity of slanting the pipe 48. The fixture 44 would then be connected directly to the inlet 22 of the water heater 20 as shown by phantom lines 50.

As hot water is drawn from one or more fixtures 44 in FIG. 2, hot water from water heater 20 will continuously entrain cold water from inlet pipe 28 in the jet entrainer 26 and be mixed in the mixing chamber 42. As hot water is drawn from outlet 24, additional cold water will be introduced to inlet 22 from the cold water inlet 28 via pipe 56.

The check valves 34 are added between the cold water inlet 28 and the jet entrainer 26 and the hot water outlet 24 and the jet entrainer 26 to insure that water can only travel in one direction and that is toward and through the jet entrainer 26. For example, if water is being drawn off at additional fixture 54, the check valve 34 at the inlet 26 of the jet entrainer 26 will prevent cold water from inlet 28 from passing through the jet entrainer 26 and out fixture 54.

FIG. 3 discloses an embodiment of a system of the present invention which would be typical where all of the fixtures 44 are relatively close together such as a plurality of wash basins, shower stalls and the like. Hot water from the outlet 24 of water heater 20 is piped via a hot water balancing valve 38 to nozzle inlets 30 of a plurality of jet entrainer 26. Cold water is piped from the cold water inlet 28 to both the inlet 22 of the water heater 20 and the inlets 36 of the aforementioned jet entrainer 26, via cold water balancing valves 32. Fixtures 44 are connected to the outlet 40 of the jet entrainer 26. Mixing chambers 42 may be added at the outlet 40 if more thorough mixing of the hot and cold water is desired. The cold and hot water balancing valves 32, 38, respectively, function in the same manner as those described with reference to FIG. 1. If the fixtures 44 are a row of shower fixtures and hot water is being drawn from all of them at the same time, and one or more is suddenly shut off or there is a surge in the pressure of the hot or cold water entering the mixing devices 26, there will be no fluctuation in the temperature of those fixtures remaining on, thus, eliminating the possibility of scalding. This is because any increase in the flow of hot water through the nozzle inlet 30 will result in a corresponding and proportional increase in the amount of cold water being entrained from inlet 36, thus, the temperature remains constant. Conversely, if there is a surge in the pressure of the cold water entering the inlet 36, the amount of hot water entering the nozzle inlet 30 will also increase due to the fact that the cold water is also being fed to inlet 22 of the water heater, thus, a proportional amount of cold water will be entrained by the hot water.

FIG. 4 discloses another embodiment of a system of the present invention wherein the fixture 44 is, for example, a conventional shower head. In this embodiment, air rather than cold water is mixed with the hot water entering the jet entrainer 26. The outlet 40 of the jet entrainer 26 is connected to the fixture 44 and the nozzle inlet 30 is connected to the outlet 24 of water heater 20 which is supplied with cold water at inlet 22. Air is introduced at the inlet 36 and mixes with the hot water in the mixing device 26 to both temper the hot water to the desired temperature as well as airiate it. Balancing valves may be added as shown in FIGS. 1 – 3. The shower of this embodiment will use substantially less water without materially changing the cleansing and other effects produced by conventional shower heads.

Referring to FIGS. 6 and 7, the jet entrainer 26 and mixing chamber 42 are shown. The jet entrainer 26 comprises a conventional hollow tee-shaped pipe fitting 58 made of copper, brass, plastic or other suitable material. The tee-shaped fitting 58 has a cross-member having a first section 60 terminating at inlet 30, a second section 62 terminating at outlet 40 and a stem section 64 terminating at inlet 36. The first section 60 has a lip 66 which extends substantially around the inside of first section 60 at the point where the inside surface of first section 60 meets the inside surface of stem section 64. The tee-shaped fitting 58 is commercially available at all plumbing supply stores in a variety of sizes. One manufacturer of such fittings of copper or brass is the Mueller Brass Company.

A nozzle 68 is provided having a hollow cylindrical portion 70 and a hollow cone-shaped portion 72. The cone-shaped portion 72 has a recess 74 which is cylindrical and axially aligned with the cylindrical portion 70. The location around the periphery of the nozzle 68 where the base of the cone-shaped portion 72 has the same outer diameter as that of the cylindrical shaped portion 70 is indicated by the reference number 76. The outside diameter of the cylindrical portion 70 is just slightly less than the inside diameter of the hollow cylindrical first section 60 of tee-shaped fitting 58 to thereby permit insertion of the nozzle 68 into the first section 60. In its assembled form, the nozzle 68 is positioned at the point where the location 76 abuts the lip 66. The length of the cone-shaped portion 72 and diameter of the recess 74 are chosen such that when it is in its assembled form in the tee-shaped fitting 58, the desired combining ratio is achieved between the fluid entering the nozzle 68 and the fluid being entrained by the jet stream leaving the recess 74. The fluid being entrained by the jet stream is introduced at inlet 36.

The mixing chamber 42 comprises a first reducing coupling 78, a second reducing coupling 80 and a connecting tubular member 82 made of copper, brass, and plastic or other suitable material. The reducing couplings 78, 80 and tubular member 82 are also commercially available at plumbing supply stores in a variety of sizes and are manufactured in brass and copper by the Mueller Brass Company. The reducing coupling 78 is chosen such that its larger inside diameter is the same as the inside diameter of second section 62 and its smaller diameter is the same as the smaller diameter of reducing coupling 80. The tubular member 82 has an outside diameter slightly smaller than the inside diame-

ters of reducing couplings **78, 80.** The larger inside diameter of reducing coupling **80** is so chosen to enable it to be connected to a distribution system as set forth in FIGS. 1 – 4. The mixing chamber 42 is connected to the outlet **40** by means of a tubular member **84** whose outside diameter is slightly less than the inside diameter of the second section **62** and the large inside diameter of reducing coupling **78.**

The jet entrainer **26** when used in the water heating system of FIG. **1,** for example, would operate as follows. Cold water fed under pressure to the inlet **30** of nozzle **70** creates the controlling or driving force. The high velocity jet stream created by the cold water being forced through the nozzle recess or orifice **74** entrains hot water in the confluent chamber **75** immediately adjacent the orifice **74.** The hot water is fed to the confluent chamber **75** under pressure from water heater **20** and encases the jet stream. The cold water jet stream from the orifice **74** and the hot water entrained thereby in the confluent chamber are then forced through the mixing chamber **78, 80, 82.** The cold and hot water are thoroughly mixed in this mixing chamber and flow from outlet 40 thereof at a preset and constant temperature.

When the pressure of the cold water entering the nozzle 70 drops, the velocity of the jet stream from recess **74** is reduced and the amount of hot water being entrained in the confluent chamber by the jet stream is therefore correspondingly reduced. Conversely, if the pressure of the cold water entering the nozzle **70** increases, the velocity of the jet stream from recess **74** is increased, and the amount of water being entrained in the confluent chamber is thus increased correspondingly. The ratio of hot water to cold water therefore remains constant as does the temperature of the mixed hot and cold water regardless of pressure fluctuations in the cold water entering inlet **30** of nozzle **70.**

If a drop in pressure occurs in the hot water entering the confluent chamber from inlet **36,** the reduced pressure in the chamber offers less head or resistance to the jet stream emanating from recess 74. This reduction in the head pressure results in an increase in the velocity of the jet stream which in turn causes the jet stream to entrain more hot water to thereby maintain the desired ratio of hot to cold water and keep the temperature of the mixture constant. The converse is also true, if the pressure of the hot water entering the confluent chamber from inlet **36** is increased, the increase in pressure will increase the resistance to the jet stream emanating from recess **74.** This increase in the head pressure results in less hot water being entrained and therefore the aforementioned ratio and temperature remain constant.

If there is an increase or decrease in the head pressure at the outlet of the jet entrainer **26** reflecting the demand for water from the entrainer by one or more fixtures **44,** the velocity of the jet stream from recess **74** will correspondingly decrease or increase and thereby entrain a correspondingly lesser or greater amount of the water fed under pressure to the confluent chamber **75** to thereby maintain the aforementioned ratio and temperature remain constant.

To make the jet entrainer **26,** one would select a tee-shaped pipe fitting **58** having a first section **60** and a stem section **64** whose inside diameter corresponds to the outside diameter of the pipes feeding fluid thereto. A nozzle **68** would then be selected having a cone-shaped portion **72** and recess **74** of the proper length and diameter respectively to provide the proper or desired mixing ratio when the nozzle **68** is in its installed position within the fitting **58.** After the proper tee-shaped fitting **58** and nozzle **68** have been selected, the nozzle **58** is inserted into the first section **60** until the location **76** engages the lip **66.** The nozzle **68** is then soldered, welded or glued depending on the material of which the elements are made to thereby provide a watertight seal between the nozzle **68** and first section **60.** A mixing chamber 42 is then constructed by joining the first and second reducing couplings **78, 80** to the tubular member **82** to form a watertight seal. The mixing chamber **42** so constructed is then joined to the second section **62** by providing a tubular member **84** which fits within the second section **62** and first reducing coupling **78** and is secured thereto by soldering or the like to form a watertight seal.

A preferred form of jet entrainer **26** and mixing chamber **42** for use in a residence having a ¾-inch cold water inlet **28,** a ¾-inch hot water supply **24,** ½-inch piping in the system, and a mixing ratio of one part cold water to one part hot would require a ¾-inch tee-shaped fitting **58,** a nozzle **68** having a cone-shaped portion **72** whose length (*a*) is approximately 1.25 inches and a recess **74** having a diameter of .125 inch. When the nozzle **68** is in position within tee-shaped fitting **58,** the distance (*b*) between the end of recess **74** and outlet opening **40** should be approximately .125 inch in order to obtain proper entrainment of the fluid encasing the jet stream. For the foregoing example, the mixing chamber **42** would use a ¾-inch by ⅜-inch reducing coupling **58,** a ⅜-inch tubular member **82** and a ⅜-inch by ½-inch reducing coupling **80** for connection to the fixtures **44** and other piping in the system. The dimensions of the pipe and pipe fittings **24, 28, 43,** 58, 70, 78, 80, 82 and **84** are nominal dimensions. The dimensions of (*a*), (*b*), and recess **74** are in actual inches.

FIG. 8 shows another embodiment of the jet entrainer 26 of FIG. 7, which when used in the previously discussed hot water systems enables the temperature of the water at the output of the entrainer to be maintained within plus or minus 1° F., of the desired set temperature despite variations in the pressure of either the hot or cold water entering the entrainer or variations in the head pressure at the output of the entrainer. This high degree of stability is achieved by using only one jet stream, i.e., the jet stream emanating from the nozzle and maintaining the velocity component of the water in the confluent chamber in the direction of the jet stream zero or practically negligible in comparison to the velocity of the jet stream itself. Thus, by permitting the water under pressure in the confluent chamber to surround or encase the jet stream, the amount of water in the confluent chamber entrained by the jet stream will vary correspondingly with the velocity of the jet stream or the pressure exerted on the jet stream by the water fed to the confluent chamber. The temperature of mixed water at the output of the jet entrainer will therefore remain constant. The method by which the jet entrainer responds to pressure variations in either the hot or cold water fed to the jet entrainer or in variations in the head pressure at the output of the jet entrainer is the same as that previously described with respect to the jet entrainer **26** and mixing chamber **42** of FIGS. **6** and 7.

The jet entrainer **90** comprises a tee-shaped pipe fitting **92** having a cross-member with a first section **94,** a second section **96** and a stem section **98.** The first section **94** has a lip **100** which extends substantially around the inside of the first section **94** at the point where the inside surface of the first section **94** meets the inside surface of the stem section **98** and the second section **96** has a lip **102** extending around the inside of the section section **96** at a point where the inside surface of the second section **96** meets the inside surface of the stem section **98.** The tee-shaped fitting **92** is also commercially available.

A nozzle **104** is provided having a hollow cylindrical portion **106** and a hollow cone-shaped portion **108.** A ridge **110** is formed on the nozzle **92** which engages the lip **100** when the nozzle **92** is inserted into the first section **94** to insure proper positioning of the end **112** of the nozzle. The end **112** of the nozzle **92** has a recess or orifice **114** of a diameter (*c*). A mixing chamber **116** is also provided in the form of a cylinder having a bore **118** of diameter (*d*). The mixing chamber **116** has an end surface **120** which engages the lip **102** when the mixing chamber **116** is inserted into the second section **96** and which end surface **120** extends to the bore **118.** As water from the jet stream and the water entrained thereby are forced into the bore **118,** they are mixed together throughout the length of the bore **118** as well as the outlet **119.**

When the nozzle **92** and mixing chamber **116** are in position within the first and second sections **94, 96,** the centerline of the recess **114** and the centerline of the bore **118** are coincident and the end **112** of the nozzle **104** is spaced from the end **122** of the bore **118** a distance such that the area formed by the closest distance (*e*) between the outside surface of the nozzle **104** and the end surface **120** of the mixing chamber **116** when the distance (*e*) is rotated about the centerline is substantially equal to the difference between the area of orifice **114** having a diameter (*c*) and the area of bore **118** having a diameter (*d*). The space between the nozzle **104** and the mixing chamber **116** forms a confluent chamber **124.**

A preferred arrangement of a jet entrainer **92** capable of achieving a mixing ratio of one-to-one between the amount of fluid emanating from the recess **114** and the amount of fluid entrained from the confluent chamber **124** and capable of maintaining the temperature of the mixed water at the output of the mixing chamber **116** to plus or minus 1° F., would have recess diameter (*c*) of 0.1250 inch, a mixing chamber bore diameter (*d*) of 0.1875 inch and an area formed by the distance (*e*) of 0.0153 square inch.

When the jet entrainer **26** of **90** of the present invention is used in an open loop system, i.e., one with no feedback, pipe **43** or return pipe of the hot water to the input of the water heater **47, 50,** the capacity (gallons of hot water per hour) of a conventional water heating system can be substantially increased.

For example, if city water at 50° F., is introduced to a water heater set at 100° F., having a 50-gallon capacity and a 50-gallon recovery rate per hour, it will produce 150 gallons of 100° F., water per hour with an electrical power consumption of 12 kilowatts. If the same water heater is used with the jet entrainer of the present invention having a one-to-one mixing ratio of hot to cold water and the water heater is set at 150° F., it will produce 200 gallons of 100° F., water per hour for the same electircal power consumption of 12 kilowatts. Further, if the same water heater is used with the jet entrainer of the present invention having a one-to-two mixing ratio of hot to cold water, and the water heater is set at 200° F., it will produce 246 gallons of 100° F., water per hour again for the same electrical power consumption of 12 kilowatts.

As can be seen from the foregoing, the capacity of a conventional water heater can be increased from between 30 to 60 percent for the same exact power consumption by the water heater. The reason is basically because the water heater can be operated at higher temperatures which is more efficient without the danger of scalding at the high temperatues because of the previously discussed operation of the unique jet entrainer of the present invention.

The water hammer suppressor of the present invention can be connected to either the inlet **128** of the nozzle **104,** the inlet **130** of the confluent chamber **124,** or the outlet **119** of the mixing chamber **116** as shown in FIG. **8** depending on where surge pressures are known to exist and may be connected to all three **119, 128,** 130 if necessary. For simplicity, the water hammer suppressor will be described with respect to the outlet **119** of the mixing chamber **116.**

The suppressor comprises a first tubular member **132** which is connected to the mixing chamber outlet **119** and extends a minimum distance (*f*) from the end **134** of the mixing chamber **116** to the end **136** of the first tubular member **132.** The minimum distance (*f*) is preferably 6 inches. The first tubular member **132** is concentric with a second tubular member **137** which is connected to the mixing device **116** and to the piping of the system for distribution of the heated water to one or more fixtures **44.** Upon installation of the first tubular member **132** into the second tubular member **137,** an air chamber **138** is formed between the concentric members **132, 136** extending a distance (*f*). Shock waves travelling down the second tubular member **137** as a result of the sudden closure of a fixture **44** compress the air in the air chamber **138** to thereby cushion the shock wave and eliminate the pounding or "water hammer" noise resulting therefrom. It has been found that to extend the first tubular member **132** into the second tubular member **136** a distance (*f*) of less than 6 inches will not provide an air chamber **138** of sufficient volume to adequately eliminate the aforementioned "water hammer" noise.

Having illustrated and described embodiments of this invention in some detail, it will be understood that these descriptions and illustrations have been offered by way of example, and that the invention is to be limited in scope only by the appended claims.

What is claimed is:

1. A system for supplying heated water at a constant temperature from a source to the inlets of a plurality of fixtures, said system comprising:

a. water heater means having an inlet and an outlet, said outlet providing said source of heated water, and

b. jet entrainer means having a first and second inlet and an outlet, said first inlet being connected to said outlet of said source of heated water, said second inlet being connected between a nozzle and a source of relatively cold water, and said outlet of said jet entrainer being connected to each of said inlets of said plurality of fixtures, said nozzle being

positioned in said entraining means for providing a high velocity stream of water which entrains water from said first inlet in proportion to its velocity to thereby maintain the temperature of the water at said outlet of said entrainer means substantially constant.

2. The water heating system of claim 1 further comprising mixing chamber means connected to the outlet of said jet entrainer means.

3. The water heating system of claim 1 wherein the outlet of said jet entrainer means is also connected to the inlet of said water heater means.

4. The water heating system of claim 1 further comprising first balancing valve means connected between said source of cold water and the second inlet of said jet entrainer means and second balancing valve means connected between the outlet of said water heater means and said first inlet of said jet entrainer means.

5. The water heating system of claim 1 wherein said inlet of the fixture at the location of intended use is connected to the inlet of said water heater means.

6. The water heating system of claim 1 further comprising mono-flow means connected between the outlet of said jet entrainer means and said fixtures, said mono-flow means being further connected to the inlet of said water heater means.

7. The water heating system of claim 4 further comprising first check-valve means connected between said source of cold water and the second inlet of said jet entrainer means and second check-valve means connected between the outlet of said water heater means and said first inlet of said jet entrainer means.

8. A system for supplying heated water at a constant temperature from a source to the inlets of a plurality of fixtures, said system comprising:

a. water heater means having an inlet and an outlet, said outlet providing said source of heated water, and

b. jet entrainer means having a first and second inlet and an outlet, said first inlet being connected between a nozzle and said outlet of said source of heated water, said second inlet being connected to a source of relatively cold water, and said outlet of said jet entrainer being connected to each of said inlets of said plurality of fixtures, said nozzle being positioned in said entraining means for providing a high velocity stream of water which entrains water from said second inlet in proportion to its velocity to thereby maintain the temperature of the water at said outlet of said entrainer means substantially constant.

9. The water heating system of claim 8 wherein said source of cold water is also connected to the inlet of said water heater means.

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