Sept. 5, 1933. F. W. OFELDT 1,925,643

METHOD OF HANDLING LIQUID

Filed June 14, 1930 3 Sheets-Sheet 1

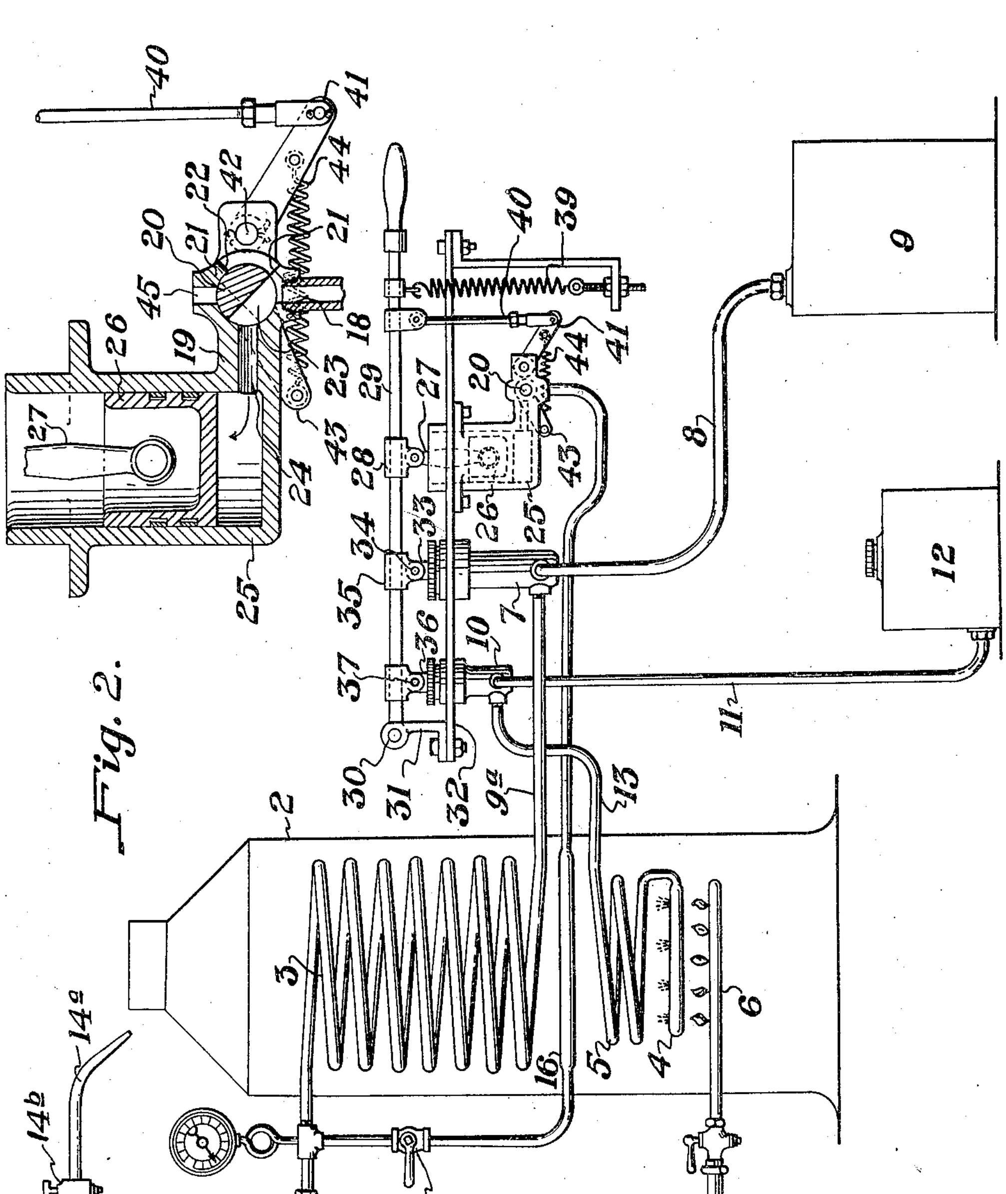

Fig. 2.

Fig. 1

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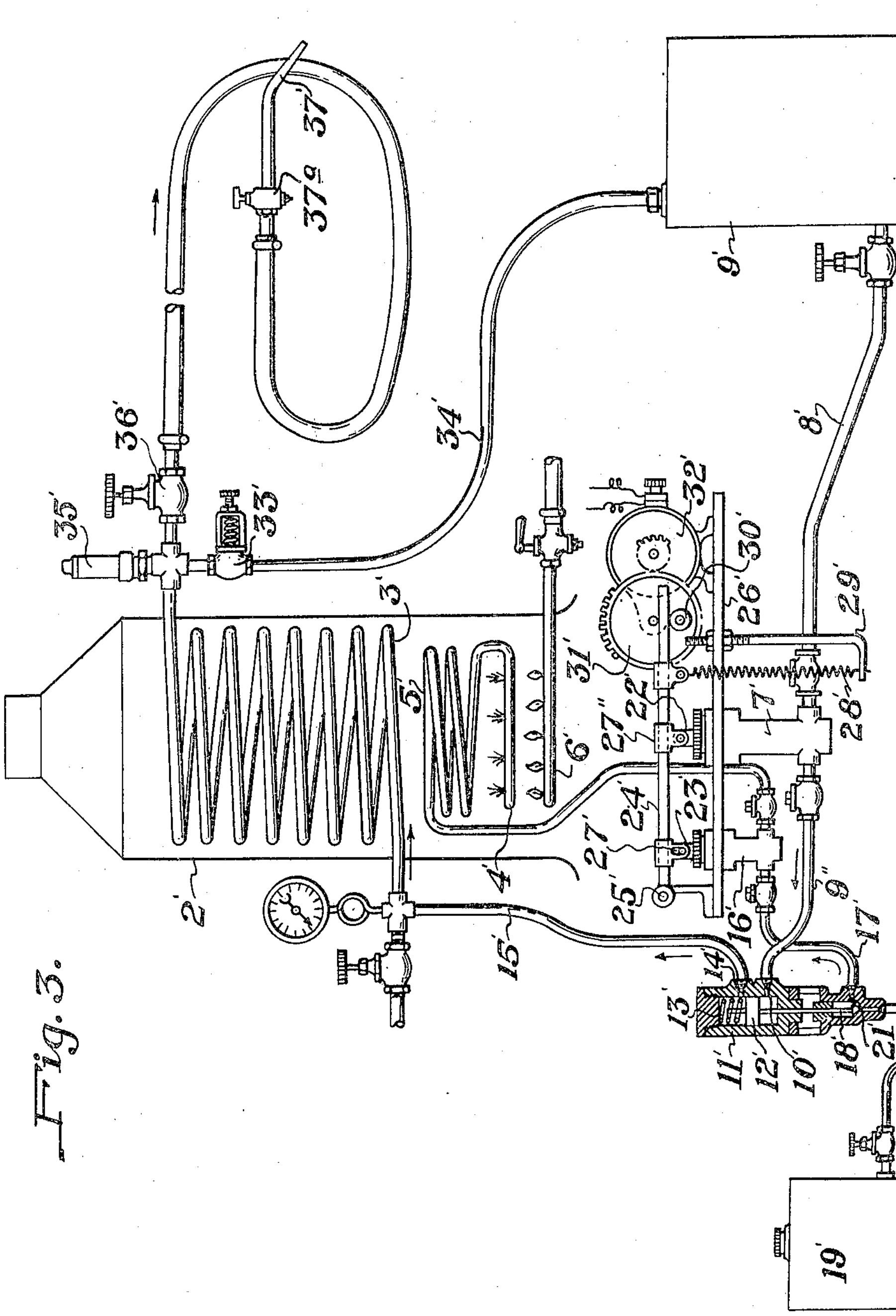

Fig. 3.

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Fig. 4.

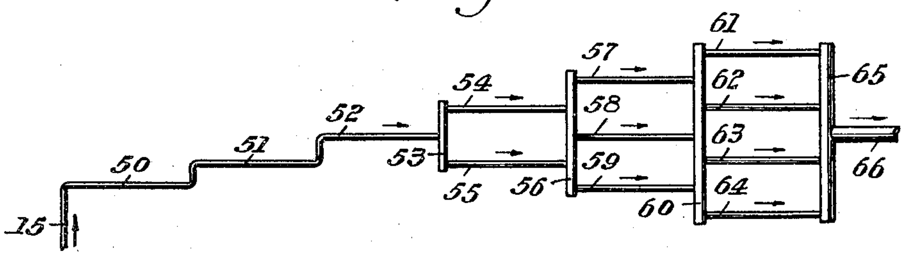



Fig. 7.

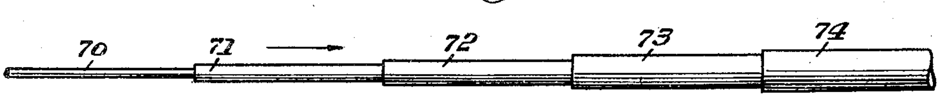



Fig. 5.

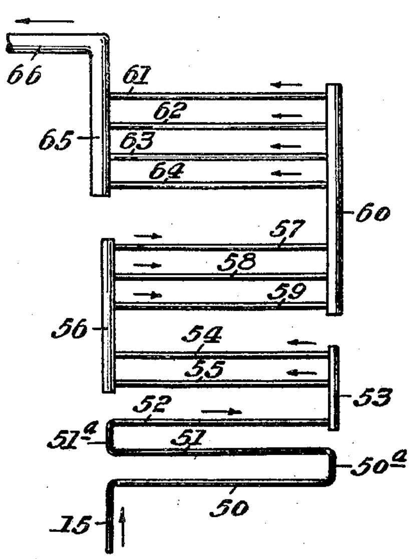
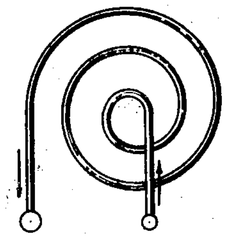



Fig. 6.



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# UNITED STATES PATENT OFFICE

1,925,643

## METHOD OF HANDLING LIQUID

Frank W. Ofeldt, McKeesport, Pa.

Application June 14, 1930. Serial No. 461,078

7 Claims. (Cl. 299—84)

My invention relates to the production of a jet of a mixture of liquid and vapor for use in cleaning or spraying. The liquid may contain a solution or suspension of cleaning or spraying material. Although the invention is described hereinafter as using hot water and steam, other liquids and vapors may be employed.

The invention operates on the well known principle that, when water under pressure is heated to a sufficient temperature and the pressure is then released, a portion, at least, of the water flashes into steam. I make use of this principle by providing means for heating water under pressure to a temperature below the boiling point at such pressure. When the pressure is released, part of the hot water flashes into steam and forms a jet composed of a mixture of hot water and steam. An atomized high-velocity spray results which is very effective in many cleaning and spraying operations.

In my Patent No. 1,855,866 for Improvement in heating and cleaning apparatus granted to me on April 26, 1932, I have described and claimed suitable apparatus for carrying out my present invention.

I thus make use of the velocity created by the initial pressure under which the water is heated as well as the additional velocity created by the vaporization of part of the water, for ejecting the mixture from a conduit. The jet is finely atomized not only by the vaporization of part of the water into steam but also by internal expansion of drops of liquid discharged from the jet.

In accordance with the invention, I provide a portable spraying apparatus comprising a heating coil having a suitable burner, pumps for supplying water to the coil under pressure and fuel to the burner, and a valve-controlled nozzle connected to the outlet of the heating coil. Fuel and water reservoirs are also part of the equipment. With the discharged nozzle closed, water is supplied to the heating coil under pressure by the water pump and is there heated by means of the burner to a temperature below the boiling point at the pressure exerted by the pump. When these conditions are obtained, the device is ready for use. If the nozzle is opened, the heating coil containing water under pressure is vented to the atmosphere and a jet of atomized water particles is created, with the velocity due to the pressure exerted by the pump, in addition to the velocity of the steam which results from partial vaporization of the hot water due to the drop in pressure. This drop in pressure between the system and atmosphere is sufficient to flash a portion of the water into steam which is effective, aided by the initial pressure set up by the pump, to eject a mixture of water and steam from the nozzle. As previously stated, the steam not only attains a high velocity which is imparted to the water, but also tends to produce a mixture with the water so that atomization thereof results.

In view of standard specifications established by the Boiler Code Committee of the A. S. M. E., it is desirable that the apparatus be proportioned and operated in such manner that, at all times when the apparatus is standing by preparatory to an actual period of operation, the pressure and temperature conditions within the system will be such that the water is maintained at a temperature below the boiling point at the prevailing pressure. Under such conditions, steam will not be generated within the apparatus during idling periods. This makes it unnecessary to provide a licensed engineer in charge of the equipment. It will be apparent, however, that it is entirely feasible where, for example, a licensed engineer is available, to so proportion the apparatus as to maintain at all times a body of water at some point within the system which is above the boiling point at the pressure existing at that point.

With either system of operation the desired results will be obtained, since in both cases there will be an initial pressure available, effective for discharging the water and imparting velocity thereto, and since in both cases the body of water will be superheated relative to atmospheric pressure, and therefore will tend to flash into steam when the nozzle is opened for commencing a period of cleaning or spraying.

My invention also contemplates the provision of a novel form of heating coil for the practice of the method hereinabove set forth. I provide a heating coil which is of gradual increasing cross-sectional area, the larger portion of the coil being disposed at the top thereof. The novel heating coil may take the form of a single conduit having sections of increasing cross-sectional area or, preferably, may be formed of sections having different numbers of pipes of uniform size connected in parallel between headers.

In the accompanying drawings there is shown, more or less diagrammatically, for purposes of illustration only, a preferred embodiment of the present invention, it being understood that the drawings does not define the limits thereof, as changes in the construction and operation disclosed therein may be made without departing either from the spirit of the invention or the scope of my broader claims. In the drawings,

Figure 1 is a diagrammatic view illustrating one manner of carrying out the present invention;

Figure 2 is a detailed sectional view, on an enlarged scale, through a portion of the apparatus;

Figure 3 is a view similar to Figure 1, showing a modified form of system;

Figure 4 is a developed diagrammatic view of a heating coil constructed in accordance with the invention;

Figure 5 is a similar view showing the heating coils as built up into a unit;

Figure 6 is a diagrammatic plan view of one of the coils; and

Figure 7 is a view similar to Figure 4, showing a modified form of heating coil.

In accordance with the present invention, there may be provided a suitable casing 2 of any desired construction having supported therein, in any preferred manner, a coil 3 for the fluid to be heated. Positioned in heat conducting relationship below the coil 3 is a burner 4, herein illustrated as being of the liquid fuel type, although the utility of the invention is not limited in this respect. Located about the burner 4 is a vaporizing coil 5 through which the fuel passes on its way to the burner.

Positioned in cooperative relation to the burner 4 is a pilot 6 effective at such times as the burner 4 is out of operation for maintaining a predetermined temperature condition within the coils 3.

Located at any convenient point exterior of the casing 2 is a pump 7 having a connection 8 with a reservoir 9 or other source of liquid which it is desired to heat. The discharge connection 9*a* from the pump 7 leads to one end of the coil 3 for supplying the liquid thereto.

Mounted adjacent the pump 7 is a second pump 10 controlling the supply of fuel to the burner 4. This second pump has a supply connection 11 leading from a suitable source of fuel supply 12. The outlet connection 13 of the pump 10 communicates directly with one end of the vaporizing coil 5, the opposite end of which delivers to the burner 4.

The coil 3 is provided with an outlet connection 14 adapted to be controlled by a valve 15 for regulating the discharge of hot water or steam from the coil. A nozzle 14*a*, having a throttle valve 14*b* is connected to the outlet 14. Intersecting the connection 14 is a superheating connection 16 provided with a control valve 17. This superheating connection has a portion or portions thereof disposed in heat receiving relation to the burners 4 and 6, the parts being so designed that at least a portion of the liquid passing through the superheating connection will be converted into steam. This steam is delivered from the superheating connection to an inlet port 18 in a valve casing 19. Mounted within the valve casing is an oscillating valve 20 of the two-way type, having its position in either extreme determined by stops 21 in the casing cooperating with a projection 22 on the valve.

With the parts in the position illustrated in detail in Figure 2, steam passes through the port 23 in the valve 20 to the passageway 24 communicating with the interior of a cylinder 25. Operatively mounted within this cylinder is a piston 26, the piston rod 27 of which is connected to a cross-head 28 slidably mounted on an operating lever 29. The operating lever has a pivotal mounting 30 on a bracket 31 carried by a suitable support 32. The piston rod 33 of the pump 7 has a similar pivotal connection 34 with a cross-head 35, and the piston rod 36 of the pump 10 has a pivotal connection 37 with a cross head 38.

The pumps 7 and 10 are originally so proportioned and designed that during the normal operation of the apparatus they will be effective for delivering the desired amounts of liquid and fuel, respectively, to the coil 3 and the burner 4, the proportion being such that the amount of fuel supplied will heat the liquid to the desired temperature. By relative adjustment of the cross heads 35 and 38 along the lever 39, this proportion can be varied within certain limits, since such an adjustment will effect a corresponding variation of the stroke of the pistons of the respective pumps.

With steam supplied to the cylinder 25 below the piston 26, the piston will be moved upwardly against the action of a return spring 39, thereby producing an intake stroke of the pistons 33 and 36, respectively. As the piston continues its upward movement, it is effective through a link 40 for rocking a crank arm 41 having a pivotal mounting 42 in the valve casing. At a predetermined time in the movement of the lever 29, the crank arm 41 will have been moved to such a position relatively to the operating arm 43 on the valve 20, that the tension spring 44, operatively connected to the arms 41 and 43, will extend above a center line connecting the points of attachment of the opposite ends of the spring and passing through the axis of rotation of the valve 20. At this time the valve will be snapped to its dotted line position, as shown in Figure 2, thereby placing the passageway 24 in communication with the exhaust port 45. At this time the return spring 39 will be effective for producing a movement of the lever 29 in the opposite direction to produce an ejection stroke of the pumps 7 and 10.

As the lever 29 approaches a predetermined lower position, the spring 44 will produce an opposite movement of the valve 20, thereby again admitting steam to the lower end of the cylinder 45. This operation will continue so long as the pressure within the coil 3 is low enough to permit the return spring 39 to function against such pressure. When the pressure exceeds this predetermined setting, the return spring will be ineffective for producing a return movement of the lever and it will remain in its upper position. This will cut both of the pumps out of operation, as will be apparent.

Should there be a failure of liquid supply to the pump 7, there will be a corresponding failure of liquid to the superheating connection 16, so that steam for operating the prime mover will not be available. In that case the lever 29 will cease to operate, which, in turn, will cut off any further supply of fuel to the burner 4.

In use, the device is started by pumping fuel to the burner and water to the heating coil by operating the pumps manually. When the water under pressure in the heating coil has been heated to a temperature below the boiling point at that pressure, the device is ready for use. The temperature attained depends on the rate of fuel feed or on the comparative capacities of the fuel and water pumps.

As before pointed out, while the conditions are preferably such that actual vaporization does not normally occur within the system itself during periods of non-use, such a condition is not essential. Normal steam generation within the system during periods of non-use is, however, objectionable not only for the reasons pointed out with respect to A. S. M. E. specifications, but for the further reason that steam generation tends to increase the rate of solid deposit within the coils.

The valve 15 is opened and the spraying may subsequently be controlled by the throttle valve 14*b*. At this time, the heating coil and the hose connection between it and the nozzle, are filled with water containing the cleaning or spraying material, the water being maintained at the required temperature by the burner. There is preferably no boiling or vaporization at this time. When the throttle valve 14*b* is opened, the pressure on the hot water is released so that somewhere in the system in advance of the nozzle, a portion of the water flashes into steam. This steam atomizes the remainder of the water and causes the emulsion to attain a high velocity. This velocity is in addition to that resulting from the pressure imposed on the heated liquid by the feed water pump. The steam itself atomizes the water and the mixture is ejected from the nozzle. After emission from the nozzle the water is further atomized by its own expansion resulting from the decrease in pressure.

When the required spraying or cleaning operation has been completed, the valve 14*b* is closed and, when the pressure has been restored in the heating coil 3, all vapor trapped therein is condensed and the system is kept ready for further use.

Figure 3 illustrates a modified form of the invention according to which there may be provided a suitable casing 2′ of any desired construction having operatively positioned therein a coil 3′ for the fluid to be heated. Located in heat conducting relationship within the casing 2′ below the coil 3′ is a burner 4′, herein illustrated as being of the liquid fuel type. Mounted above the burner 4′ is a vaporizing coil 5′ through which the oil passes on its way to the burner. A suitable pilot burner 6′ is mounted in the casing below the burner 4′ in such manner as to maintain the coils 5′ in partially heated condition.

Located at any convenient point exteriorly of the casing, is a pump 7′ having a connection 8′ with a reservoir 9′ or other source of water or cleaning liquid supply. The discharge connection 9′′ from the pump communicates through a port 10′ with the interior of the casing 11′ of a suitable flow control valve. With water flowing through the connection 9′′, the piston 12′ in the casing 11′ will be lifted against the action of the spring 13′ to thereby uncover the outlet port 14′. This port has a connection 15′ to the coil 3′.

Mounted adjacent the pump 7′ is a second pump 16′ for the fuel oil, this pump having a supply connection 17′ communicating with a chamber 18′ in the casing 11. The chamber 18′ receives a supply of fuel from a suitable reservoir 19′ through a connection 20′, the flow being controlled by a needle valve 21′ connected to the piston 12′. By reason of this construction, it will be apparent that with no liquid flowing through the connection 9′′, the spring 13′ will be effective for seating the valve 21′. With liquid flowing, the valve 21′ will be held away from its seat, thereby permitting the passage of fuel oil to the pump 16′. The pumps 7′ and 16′ are so located that the piston rods 22′ and 23′ thereof may be operatively connected to a single lever 24′ having a pivotal mounting 25′ on a support 26′. The piston rod 22′ preferably has a pivoted connection 27′ with the lever 24′, while the piston rod 23′ is connected to this lever to provide a slight lost motion with respect thereto. This may be accomplished by means of the pin and slot 27′′.

The lever 24′ is normally urged in the full line position illustrated in the drawings by a tensile spring 28′ connected at one end to the lever, and at its opposite end to an adjustable spring support 29′. By suitable adjustment of the support, the tension of the spring may be varied. The lever 24′ is moved in the opposite direction against the action of the spring 28′ by means of a roller 30′ eccentrically mounted on a gear 31′ driven by a motor 32′. With the construction described, starting the motor 32′ will effect rotation of the gear 31′ and thereby cause the roller 30′ to lift the lever 24′. The lever will be returned as the rotation of the gear 31′ continues by the action of the spring 28′. Since the downward stroke of the lever 24′ is effective for expelling liquid from the pumps 7′ and 16′, it will be obvious that the maximum pressure of liquid in the system at any time, not having regard for temperature conditions, will be determined initially by the spring 28′. When the pressure reaches such a point that the spring 28′ is ineffective for moving the lever downwardly its complete distance, the roller 30′ will only be effective on the lever during a portion of each rotation of the gear 31′. Ultimately there will be established a condition in which the lever 24′ remains in substantially its uppermost position, whereby the movement imparted thereto by the roller 30′, while effective for moving the piston rod 22′, will not be effective for moving the piston rod 23′ by reason of the lost motion connection 27′′ provided. This insures continued supply of cleaning liquid to the coils 3′ after the pump 16′ becomes ineffective for supplying further fuel oil to the burner 4′. This constitutes a safety factor preventing excessive increase in temperature in the apparatus such as might result from the combined action of the pilot 6′ and burner 4′ with a small amount of water flowing.

Any excess water supplied to the coil 3′ by reason of the continued action of the pump 7′ may escape from the coil past a suitable relief valve 33′. This relief valve is preferably located in a connection 34′ leading to the reservoir 9′ or other source of supply. In the event of excessive pressure by reason of the heat supplied to the coils 3′ sufficient to generate steam, such steam may escape through a safety valve 35′ of any standard construction.

In actual practice, the pumps 7′ and 16′ are so constructed and proportioned that under given conditions of operation there will be sufficient fuel to the burner 4′ to heat the amount of water or other cleaning liquid being handled, to the desired temperature. With the throttle valve 36′ open, the cleaning liquid at high temperature is permitted to pass under pressure to a spray nozzle 37′, by means of which it may be utilized for the purposes contemplated. With the throttle valve 36′ wide open, the pumps 7′ and 16′ will be operating substantially up to their capacity. As this throttle is closed at the end of a cleaning operation, however, the pressure will gradually build up in the system so that the spring 28′ becomes ineffective for imparting a full stroke to the lever 24′, as hereinbefore described. At such times, the continued operation of the pump 7′ after the cessation of operation of the pump 16′ insures a flow of water past the relief valve 33′ such that the boiler coil 3′ is maintained full of cleaning liquid at a temperature below the boiling point at the pressure determined upon.

This represents an idling condition during which the actual final temperature of the cleaning fluid is determined by the amount of heat supplied by the pilot 6'.

The operation of the form shown in Figure 3 is similar to that already described for the first form of the invention. The system is made ready for operation by starting the pumps to place the water in the heating coil under pressure and to supply fuel to the burner to heat the water to a temperature below the boiling point at that pressure. No vapor exists in the heating coil at this time. To use the spray, the valve 37*a* is opened, the valve 36' having been previously opened to connect the heating coil to the nozzle. Upon the opening of the valve 37*a*, the pressure on the heated liquid is released and a portion of it flashes into steam, as previously explained, to form a liquid of steam and water which is ejected from the nozzle at a high velocity imparted by the steam aided by the initial pressure on the liquid.

Although the temperatures and pressures employed may vary widely, a typical spraying system will employ a pump capable of producing a pressure in the heating coil such that the boiling point of the water at that pressure is substantially 260°. The burner and fuel pump are designed to heat the water in the coil to a maximum of 250 to 255° F. Under these conditions, of course, no vapor will be generated in the coil.

When the nozzle valve is opened, a pressure drop between the coil and the nozzle occurs which will effect a temperature drop of from 38 to 43°, assuming a boiling point of 212° in the atmosphere outside the nozzle. This drop in pressure and temperature causes the vaporization of a portion of the liquid with the results already set forth in detail. The figures given for temperature and pressure are, of course, merely illustrative since various values may be chosen in accordance with the requirements of any particular installation.

Figures 4, 5, and 6 illustrate diagrammatically a novel form of heating coil for the practice of the invention hereinbefore described. In order to provide space for the expansion of the superheated liquid when the nozzle valve is opened, it is preferable to make the portions of the heating coil nearest the discharge hose of larger cross-sectional area than the lower portion of the coil. One way of accomplishing this is illustrated in Figures 4, 5, and 6, and according to this method, I provide a plurality of sections 50, 51, and 52 of single lengths of pipe. The liquid supply conduit 15 is connected to one end of these sections and the other end is connected to a header 53. Twin conduits 54 and 55 are connected to the header 53 and extend to a header 56 from which triple conduits 57, 58 and 59 extend. Another header 60 connects the branches 57, 58, and 59 to a set of four tubes 61, 62, 63, and 64, which terminate at a header 56 having a discharge pipe 66 connected thereto. In order not to lose the benefits obtained by the increasing cross-sectional area, the discharge pipe 66 should have a cross-sectional area comparable to that of the aggregate cross-sections of the conduits 61, 62, 63, and 64, and the headers should be similarly dimensioned. The number and length of the sections, as well as the number of tubes per section, may be varied as required.

Figure 5 illustrates how the conduit shown in the developed diagram in Figure 4 may be formed into a heating coil similar to those illustrated in Figures 1 and 3. The single tube sections 50, 51, and 52 are disposed at the bottom of the coil and are connected by suitable connectors 50*a* and 51*a*. The remaining tubes are stacked vertically and connected as shown in Figure 4. Each tube is formed into a coil as shown in Figure 6, the outer terminal of the coil being the inlet, and the inner terminal, the outlet. In the upper sections of the complete coil, the individual coils are connected in parallel. The inner ends are brought out to headers to which the outer ends of the next set of coils are connected, as shown in Figure 6. Figure 5 shows the general arrangement of the heating coils in a unitary assembly, but is not intended to be complete as to details of the connections, or arrangement of the headers.

In Figure 7, I have shown a developed view of another form of heating coil. In this form the coil is made up of a plurality of sections 70, 71, 72, etc., of gradually increasing cross-sectional area, the smaller sections of the coil being disposed at the bottom thereof. These sections may be of suitable length for forming individual coils as in the case of the modification in Figures 4 through 6.

The forms of heating coil construction described permit a more effective expansion of the superheated liquid into vapor when the pressure thereon is suddenly reduced, so that a better stream of the vapor-fluid mixture is ejected from the nozzle. Fluid friction and the resulting pressure drop are also minimized and the capacity of the heating coil is increased.

Among the advantages characterizing the invention may be mentioned the fact that, since there is no boiling in the lower part of the heating coil, there is no tendency for a cleaning or spraying compound in the water to precipitate on the inner walls of the coils. In the upper part, the velocity of the mixture is sufficient to carry away any solids deposited. All clogging of the coils is thus avoided. It has already been stated that the invention produces a high velocity jet of finely atomized water and steam, which makes an effective cleaning and spraying agent. Since the cleaning or spraying material is introduced into the liquid before it goes through the system, a more thorough mixture or solution thereof is accomplished than if the material were supplied directly to the jet.

From the foregoing it will be apparent that I have provided an apparatus entirely automatic in its operation and possessing safety features in that either undue pressure or failure of liquid supply will cause the parts to cease operation. This constitutes one of the advantages of the present invention.

The construction is such that by the desired proportioning of the displacement areas of the pumps 7 and 10, the liquid flowing through the coil 3 may be heated to any desired temperature. This temperature may be such as to produce either hot water for cleaning purposes, or steam for any purposes desired. This constitutes a further advantage of the present invention.

The present construction provides a safety system in which the supply of fuel is made dependent upon the actual supply of liquid to be heated in such manner that excessive temperatures cannot be obtained.

Other advantages arise from the provision of a common operating lever for the separate pumps, which operating lever is positively actuated in one direction and yieldingly actuated in the opposite direction, whereby the maximum pressure created by the pumps themselves is limited by the yielding pressure exerted. Such a construction is particularly advantageous where a lost motion connection exists between the operating means and one of the pumps, whereby a differential action of the pumps is obtained.

Still other advantages arise from the provision of a boiler in the form of a coil 3' having a release valve insuring the escape of surplus cleaning liquid supplied by reason of the effective operation of the fluid pump 7' after the pump 16 has become inoperative.

Although I have illustrated and described but two modifications of the invention, these are the present preferred embodiments, but it is obvious that the invention may be practiced in other forms. For this reason, any changes in the construction may be made without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. In a method of producing a jet of atomized hot water and steam the steps including placing a column of water under pressure, heating the water to a temperature below the boiling point at that pressure but above the boiling point at atmospheric pressure whereby generation of steam is precluded, opening the column to atmosphere, whereby a portion of the water is flashed into steam and a mixture of steam and water ejected at high velocity.

2. In a method of producing a cleaning or spraying jet, the steps including maintaining a liquid under pressure, heating the liquid to a temperature below the boiling point at such pressure to prevent formation of vapor, but above the boiling point at atmospheric pressure, venting the liquid to atmosphere to vaporize a part of the liquid and eject a mixture of vapor and liquid.

3. In a method of vaporizing a liquid, the steps including placing it under pressure, heating it to a temperature below the boiling point at such pressure but above the boiling point at atmospheric pressure, venting the liquid to reduce the pressure thereon and permit the flashing of a portion thereof.

4. A method of ejecting an atomized mixture of liquid and vapor which includes the steps of subjecting liquid to a pressure, heating the liquid to a temperature below the vaporizing point at such pressure to prevent formation of vapor but above the boiling point at atmospheric pressure, and venting the liquid to atmosphere to partially flash the liquid into vapor whereby a high velocity is imparted to the escaping liquid and vapor.

5. A method of distributing a cleaning or spraying substance which consists in dispersing it in a liquid vehicle, subjecting the liquid to pressure sufficient to prevent vaporization, heating the liquid under pressure without vaporizing it, to a temperature above the boiling point at atmospheric pressure, and releasing the pressure on the heated liquid, whereby the liquid is at least partially vaporized and ejected forcibly.

6. In the method of handling liquids, the steps comprising maintaining a body of liquid under predetermined pressure conditions greater than atmospheric pressure at the point of use of such liquid, adding heat to such liquid to an amount to maintain the same at a temperature but slightly below the boiling point at said pressure to prevent the accumulation of vapor thereabove, delivering the liquid to a point of use, producing a pressure drop in the liquid sufficient to generate steam while the liquid is being conveyed, and utilizing the expansion of said steam and said pressure for controlling the discharge of the liquid.

7. In the method of handling liquid, the steps comprising maintaining the treated liquid under pressure sufficient to prevent the formation of vapor, adding heat thereto to such an amount as to maintain the liquid at a temperature below boiling at the pressure under which it is maintained, conveying the liquid to a point of lower pressure, producing a pressure drop during the conveyance of the liquid sufficient to generate steam and cause a directed discharge of the liquid and steam mixture.

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