Our invention relates to steam systems with special reference to steam systems for drying operations and is directed to improvements on the type of steam system set forth in the Harrison et al. Patent 2,366,322 issued January 2, 1945. The present application is a continuation-in-part of the Harrison et al. application 701,252 filed October 4, 1946 and the Tiller and Hunt application 765,628 filed July 22, 1947, both of which are abandoned. These prior disclosures, as far as consistent herewith, are incorporated in the present disclosure by reference.

Other copending applications disclosing the subject matter related hereto are: S. N. 78,605, filed February 26, 1949; S. N. 78,842, filed February 28, 1949; S. N. 78,843, filed February 28, 1949; S. N. 80,802, filed February 28, 1949; and S. N. 777,894, filed October 4, 1947.

The general object of our invention is to achieve greater efficiency in a steam system by heat conservation and better heat transfer and preferably so as to be by means of a compact automatic master control that may be manufactured as a self-contained packaged unit for incorporation in existing steam systems.

A feature of the above mentioned patented system is operation in a pulsating manner to provide pressure pulsations in the steam chests of the system and velocity surges in the return lines. Such pulsating operation is advantageous in many respects and is of special importance in reducing resistance to heat flow on the part of condensate films and films of non-condensable gas that are inevitably formed on the inside of the steam chests of heating equipment. One of the specific objects of the present invention is to provide improved pulsating action, an improved pattern of pulsation and positive control over the duration and frequency of the pulsations.

Other objects of the invention relate to the problems of control and economy in the operation of a steam system of the type set forth in the above mentioned patent. Such a steam system is characterized by the release of fluid from the return end of the system into a region of substantially lower pressure for the maintenance and regulation of flow velocity in the system. The steam system is what may be termed a "clear channel system" with open communication from the end of the return line back through the steam using equipment to the steam source (no traps) so that the velocity throughout the system will be responsive to the pressure drop at the end of the return line created by the release of fluid. In this method of operation a small fraction of the total steam survives to the end of the return line and is termed "acceleration" steam because its release accelerates velocity throughout the system.

Two problems arise in this method of operating a steam system: first, to control the release of acceleration steam effectively, and second, to make the release of steam as economical as possible. The acceleration steam must be released in such amount and such manner as to maintain a particular velocity level or range of velocity best suited for the particular steam system and for maximum economy the B. t. u.'s of the released steam must be reclaimed.

In the disclosure of the above mentioned Harrison patent these two problems of control and economy are met by using a thermostatic valve to govern the release of acceleration steam and using make-up water to cool the thermostat element of the valve. Control by the make-up water is highly satisfactory because a specific minimum make-up water demand is inherent in every steam system and may therefore serve as a reliable base for velocity regulation. And it is economical to use make-up water to cool the thermostat because the steam released by the thermostatic valve preheats the make-up water. The make-up water carries the reclaimed heat units directly to the boiler to keep them in the steam system.

It is possible to control the flow velocity of a steam system in this way by the inherent demand for make-up water by the system, no matter how small that demand may be. It is easier to establish this kind of control, however, when the make-up water demand of the steam system is of substantial quantity. In a laundry, for example, the make-up water demand is relatively high, and it may be found that 50% of the total boiler feed water is consumed in the make-up water demand. In such a situation care is taken to set up a triggering action whereby a small increment of water reaching a thermostat causes the release of a suitably larger quantity of steam. Such triggering action makes it possible to set up and regulate high
velocity flow through a steam system by means of and on the basis of a relatively small demand for make-up water. As for economy in reclaiming the heat units of the released steam by make-up water there is a limiting factor in the number of B. t. u.'s that can be transferred to a given quantity of water. This limiting factor becomes important when the make-up water demand is small while the required amount of acceleration steam to be released is relatively large.

It is apparent then that while the use of make-up water to cool the thermostat element of a thermostatic valve is practical, no matter how small the make-up water demand of a steam system, nevertheless it would be advantageous in certain situations to have available other means of controlling the release of acceleration steam and reclaiming the B. t. u.'s of the released steam.

A purpose of the present invention is to provide other means than the cooling action of make-up water on a thermostat element to achieve reliable velocity control combined with economical use of the released steam. The object is to supplement or replace entirely the cooling effect of the make-up water for creating system-wide velocity.

In various practices of the present invention, this object may be attained by recycling make-up water, by recycling condensate, by recycling a mixture of make-up water and condensate, and by withdrawing condensate from some point in the system to supplement or replace the make-up water. Other means to the same end apart from cooling action on the thermostat element of the thermostatic valve may be action carried out on the steam from the thermostatic valve. One such action may be the continual withdrawal or pumping of condensate from the return line for the creation of velocity in the system. Another such action may be the condensing acceleration steam upstream from the valve for the creation of velocity in the system.

Further objects of the invention relate to flexibility or adaptability in a control unit of the character described. Flexibility is especially important because the unit must be adapted to the specific requirements of widely different steam systems. In this regard another object of the invention is to provide an exceptionally extensive range of adjustability permitting the control unit to be "tuned" or adjusted precisely to the particular requirements of widely different steam systems.

A further object of the invention is to provide means for promoting flow velocity in the steam system by fluid released from the return side of the system without incurring the flash losses that characterize a conventional open steam system. In this regard it is proposed, in effect, to combine the advantages of open and closed steam systems, the advantage of an open steam system being the availability of a large pressure differential for creating flow velocity and the advantage of a closed steam system being the maintenance of condensate under pressure to prevent flash losses.

A further object of the preferred practice of the invention is not only to promote velocity in the system by pressure drop at the end of the return line, but also to deliver the make-up water to the boiler at a higher temperature than possible in any conventional steam system. This dual object is accomplished by transferring heat from the return line to the make-up water as the make-up water travels from the usual feed pump to the boiler. Thus the make-up water causes condensation in the return line to promote flow velocity in the system and at the same time itself is raised to a high temperature, an order of 300°F. It is possible to heat the make-up water to this high temperature and to do so without creating any pumping problem because the additional heating occurs on the discharge side of the feed pump where the water is under high pressure.

The above and other objects and advantages of the invention will be apparent in the following description taken with the accompanying drawings.

In the drawings, which are to be considered as merely illustrative:

Fig. 1 is a front elevation of a typical embodiment of the invention as a self-contained master control unit;

Fig. 2 is a diagram of a representative steam system incorporating one form of the new control unit; and

Fig. 3 is a similar diagram illustrating other practices of the invention.

Fig. 1 illustrates how the invention may be embodied in a piece of apparatus and may be manufactured as a self-contained unit for installation in steam plants, usually in the boiler room. This form of the unit includes an upright tank or receiver 18 and a housing or casing 11 associated therewith. The housing may completely enclose the tank or may, as in the present construction, extend forward from the tank to provide an enclosed space for the numerous elements that make up the control combination. The casing may be sheet metal construction with upper and lower sliding doors 12 that may be opened for access to the interior. The casing includes a panel board 13 on which are various indicating devices that will be described later.

Fig. 1 shows six pipes connected to the master control unit. These six pipes are: a pipe 14 for supplying supplemental cooling water to the unit; a pipe 15 for supplying new water to the unit; a pipe 16 connected to the discharge side of the usual boiler feed pump; a pipe 17 which is the boiler feed line for supplying water to the boiler; the return line 18 of the steam system and, at a lower level, the pipe 19 to the intake side of the boiler feed pump. If desired, an additional vent pipe 21 may be connected to the vent opening of the tank 10.

Fig. 2 shows diagrammatically the principal elements of a steam system including the important parts of the new master control unit. The parts of the unit itself are shown inside a rectangle 22 indicated by a broken line in Fig. 2. Everything inside this rectangle in Fig. 2 is inside the casing 11 of the unit shown in Fig. 1.

In the system shown in Fig. 3, steam from a boiler 23 is supplied through a header 25 to a plurality of equipment heat exchangers or steam using devices 26. Such devices may be, for example, the various machines in a laundry or the drying equipment used in paper manufacturing, plastics, etc. Return pipes 27 from the various pieces of equipment connect with the previously mentioned return line 18.

Instead of traps, each of the return lines 27 is provided with a suitable restriction such as a nipple 28 of relatively small diameter. It will be noted that in such an arrangement there will be open communication from the return line 18 back through the various pieces of equipment 26.
to the steam supply so that lowering pressure in the return line 18 will cause flow velocity responses in each of the steam units.

The return line 18 is terminally connected to the side of a steam separator 31 which preferably, but not necessarily, also serves as a heat exchanger for using the returned condensate to heat new make-up water. The combined heat exchanger and separator 31 is shaped and dimensioned to permit the condensate to separate from the steam and, if desired, suitable baffles 32 may be added to facilitate such separation.

The condensate that is separated from the steam gravitates through a pipe 33 to the intake side of a condensate pump 35 that is included in the working parts of the master control unit. The pump 35 discharges the condensate upward through a pipe 36. Preferably the pump 35 operates continuously.

A valve 37 is provided in the pipe 33 to cut the heat exchanger off from the pump if desired. When the valve 37 is closed all of the condensate and steam that reaches the heat exchanger 31 must flow from the heat exchanger through a pipe 38. The pipe 38 conducts fluid from the return line 18 into the receiver tank 19.

This pipe 33 leads to a two-stage combined heater and mixer 40 which in turn communicates with a spray head 41. Flow through the pipe 33 into the tank 10 is controlled by a thermostatic valve 42 having a thermostat bulb 43 extending into the spray head 41. The thermostat bulb 43 is so arranged that the valve opens in response to decrease in temperature of the thermostatic bulb 43 and closes in response to increasing temperature of the bulb. The critical temperature at which the valve opens and closes may be varied by virtue of a manually adjustable 45 on the thermostatic valve 42.

The steam or steam mixed with condensate that flows through the pipe 38 and the valve 42 enters a central upright passage 45 in the two-stage heater 46 and divides, one portion flowing into an upper jet 47 for the first stage heating of new water, and the other portion flowing into a lower jet 48 for the second stage heating. The upper jet 47 is directed into a Venturi throat 50 and the lower jet 48 is directed into a corresponding Venturi throat 51, each jet and throat forming a low pressure space for the introduction of fluid.

New water for the steam system from the previously mentioned supply pipe 15 passes through a float-controlled valve 52 and through a vent condenser 53 to a pipe 55 that enters the two-stage heater 46 in the low pressure space between the first jet 47 and Venturi throat 50. The resulting mixture flows through a lateral connecting passage 56 into the low pressure space between the second jet 48 and second Venturi throat 51, where it is joined by the second portion of hot fluid from the pipe 38. From the two-stage heater the heated water flows into the spray head 41 in heat exchange relation with the thermostatic bulb 43. The water is not only heated but is also under considerable pressure in the spray head 41 and is discharged downwardly through the spray ports with considerable velocity.

Preferably the tank 10 is maintained slightly above atmospheric pressure, say, 3 or 4 lbs. above atmospheric pressure. For this purpose the tank is of closed construction and the vent 21 is provided with both a vent valve 58 and a relief valve 59. The vent valve 58 may be adjusted at a slightly open position to maintain the desired pressure in the tank of 3 or 4 lbs. per square inch, and the relief valve 59 may be adjusted to pop off at, say, 8 to 10 lbs. per square inch.

It is contemplated that the spray capacity of the spray header 41 will be so limited relative to the input of fluid that the pressure in the spray header will rise above the pressure prevailing in the tank 10 when the thermostatic valve 42 is open. Under such conditions the pressure in the spray header may go substantially above the tank pressure. It is further contemplated that the extent to which pressure will rise in the spray header under given conditions may be varied either by varying the number of spray openings or changing the size of the spray openings.

When the heated water is released in finely divided particles from the spray header 41 into the interior of the tank 10, the water particles are shattered by flashing action and the non-condensable gases are effectively released from the water to escape upwardly through the vent opening 21. The vent condenser 53 not only reclaims heat from the escaping gases but also condenses any vapors that tend to escape with the gases, the recovered condensate dripping to the bottom of the tank.

The tank 10 contains in its lower portion a reservoir 60 of the de-aerated make-up water supplied by the above described spray action. When the level of this body drops, a suitable float 61 actuates the previously mentioned valve 52 by suitable mechanical means including an upwardly extending operating rod 62. If the level of the water body 60 rises too high, it overflows through an overflow pipe 63. To prevent the release of pressure through the overflow pipe 63 the overflow pipe is provided with a float valve 64 that is normally closed but opens automatically whenever the water level in the tank rises unduly. When desired, the whole water content of the tank may be flushed out by opening a drain valve 65.

In the preferred practice of our invention the master control unit is provided with means for introducing and controlling pulsations in the steam system. An example of such an expedient is the use of an intermittently operated water valve 70 shown in Fig. 2.

The water valve 70, which is in series with the previously described float valve 52 to control the water flow into the vent condenser 53, is of the solenoid type controlled by an electric circuit, the valve being open when the circuit is energized and being closed when the circuit is de-energized.

A pair of wires 71 supply current to a timer 72 and wires 73, 74 and 75 complete the circuit with the solenoid valve 70 in series with a mercury switch 76. The mercury switch 76 is on a rocker arm 77 of the float control mechanism actuated by the float 51 and closes whenever the float drops in response to demand for new make-up water. Thus, the valve 70 is intermittently operated during any period in which the float control valve 52 is open. It is apparent that the float control valve 52 may be omitted entirely if desired. The timer 72 is of a well known type and may be made adjustable to divide a fifteen-second time period into two parts in any desired proportion. For example, the timer may, in repeated cycles, cause the solenoid of the valve 70 to be energized for five seconds and de-energized for ten seconds.

The de-aerated make-up water, usually at above
The tank 10, is taken from the tank through the previously mentioned pipe 20 to the intake side of the usual boiler feed pump 67 and is discharged by the pump into the previously mentioned pipe 16 that is connected to the control unit at the top. The pipe 16 is connected to the inlet end of a heat exchange coil 68 in the previously mentioned combined heat exchanger and steam separator 31. The outlet end of this coil 68 is joined to the previously mentioned pipe 35 from the condensate pump 35 to supply the previously mentioned boiler feed line 17 as indicated in Fig. 2.

Inside the master control unit means may be provided to divert at least some of the discharge from the boiler feed pump 67 directly into the shell of the combined heat exchanger and separator 31. For this purpose the pipe in the master control unit that connects with the pipe 16 from the boiler feed pump 67 is provided with a branch 183 leading to a spray head 104 inside the separator water. Two manually adjustable valves 105 and 106 are provided as shown to permit variation in proportioning the flow between the coil 68 and the spray head 104.

The feed water pump 67 may be controlled in a well-known manner by means responsive to changes in the water level in the boiler 23 or in some practices of the invention may be manually adjusted to run continuously at approximately the rate required to keep the boiler level constant. In either event, the float 61 in the master control tank 10 will drop periodically to cause new water to be supplied to the system in accord with the boiler demand. Since the boiler demand for make-up water varies with the heat load on the system, it is apparent that the master control unit is responsive to changes in the heat load on the system.

A second expedient that may be used to create control pulsations in the system instead of the solenoid valve 70 or in addition to the solenoid valve is the use of intermittently flowing water from any suitable source entirely independent of water demand by the boiler.

In the particular arrangement shown in Fig. 2, a small circulating pump 30 has its intake 131 connected to the tank 10 to draw water therefrom. The output of the pump is delivered through a pipe 132 to the previously mentioned pipe 55 so that it may reach the thermostat 43 to cause opening action of the thermostatic valve 42. A check valve 132 prevents back flow. Preferably, a by-pass 134 having a by-pass valve 135 is provided from the discharge side of the pump back to the tank 10. This valve 135 and a second valve 136 in the pipe 132 may be manipulated to vary the amount of recirculated fluid that reaches the pipe 55.

In some instances it is desirable to cool the discharge from the circulating pump 30 for greater cooling effect on the thermostat 43. For this purpose, Fig. 2 shows the discharge from the circulating pump 130 as passing through the coil 137 of a heat exchanger 138. The heat exchanger 138 is provided with an intake pipe 39 and an outflow pipe 140 so that any suitable fluid medium may be circulated therethrough.

Similarly, the circulating pump 130 is operated intermittently to cause pulsating flow through the pipe 132 and preferably the pulsations of this flow are synchronized with the pulsations of flow through the pipe 55 when the unit is taking make-up water. For this purpose, the motor-driven pump 130 is energized by wires in a cable 141 that is connected in parallel with the solenoid valve 70 to be operated simultaneously therewith by the timer 73.

Operation

The manner in which the steam system operates and is controlled by the described unit may be understood from the foregoing description. Steam condenses in each one of the steam chests in the pieces of equipment 26 to give up heat to the material in process, but a portion of the steam flows continuously into the return line 18 through the restrictions 28 because of the open communication through the system. In this method of operation, the flow velocity is substantially higher than the overall or average velocity in a conventional trap system and the small proportion of steam that is continuously passing through the restrictions 28 effectively carries the condensate out of the steam chests along with non-condensible gases. The drop in pressure at the restrictions 28 causes some of the condensate to flash into steam thereby slightly increasing the steam content of the fluid mixture that reaches the combined heat exchanger and separator 31.

The adjustment 45 of the thermostatic valve 42 is high enough to make the valve open in an intermittent manner thereby to cause pulsating flow throughout the system. In a steam system having approximately 100 lbs. per square inch gauge pressure in the steam header 25 the setting of the thermostatic valve may be, for example, somewhat above 230° F. In any event the temperature setting of the thermostatic valve will be above the normal temperature prevailing inside the tank 10. If the tank 10 is at 4 to 6 lbs. gauge pressure the temperature therein will be in the range 224° to 230° F.

Since the temperature in the master control tank is below the temperature setting of the thermostatic valve the environment of the spray header 41 tends to cool the thermostat bulb below the temperature setting thereby to cause the thermostatic valve 42 to open. When the valve 42 opens, however, the thermostat bulb is again heated above its critical temperature by the fluid released from the separator 31 thereby causing the thermostatic valve to close.

Since a temperature above 230° F. cannot be attained in the spray head 41 as long as the spray head interior is at the same pressure as the interior of the tank 10 the initial flow of steam from the thermostatic valve or the initial flash of steam by flash action from condensate released through the valve does not have a temperature above 230° F. Since the restrictive action of the spray openings is effective to cause raising back pressure in the spray header, however, the temperature rises correspondingly and soon climbs above the temperature setting of the thermostatic valve. It is apparent then that the flow passage from the thermostatic valve 42 to the discharge openings of the spray header 41 functions as a pressure accumulation space to make possible the relatively high temperature required for the purpose of valve control as well as for the purpose of deaerating the make-up water.

By virtue of the described cycle of alternate heating and cooling, the valve 42 opens intermittently in an automatic manner to maintain a desired minimum average flow velocity in the system during periods when no new make-up water is flowing. Whenever new make-up water
is required the float 61 lowers to open the water valve 52 and at the same time the mercury switch 78 tilts to close a circuit through the solenoid valve 70 and timer 72. As long as the float 61 is lowered the solenoid valve 70 opens intermittently to release pulses of make-up water for flow through the vent condenser 83 and pipe 58 into the two-stage heater-mixer 40. Each pulse of water causes the thermostat 43 to be cooled thereby to open the thermostatic valve 42 for the release of steam from the system. The steam mixes with the new water and the new water released by the spray header 41 under pressure and at a temperature higher than 212° F. is effectively deaerated. The deaerated water drops to the bottom of the tank 10 while the released non-condensable gases flow upward to the vent 21. The vent condenser 83 not only condenses any vapors that may tend to escape but also reclaims heat from the separated gases.

In the usual method of operation the flow of new water is adequate to keep the thermostatic valve 42 open in opposition to the heating effect released by the thermostatic valve, so that the thermostatic valve stays open as long as the flow of new water continues. As soon as water flows into the two-stage heater-mixer ceases, the thermostatic valve immediately closes in response to the high temperature fluid from the return line. Thus the thermostatic valve will open and close in response to each pulse of water released by the solenoid valve 70.

This continual interruption of the water flow by the solenoid valve 70 has important effects. It increases the amplitude and abruptness of the pulses released by the thermostatic valve, so that the thermostatic valve stays open as long as the flow of new water continues. As soon as water flows into the two-stage heater-mixer ceases, the thermostatic valve immediately closes in response to the high temperature fluid from the return line. Thus the thermostatic valve will open and close in response to each pulse of water released by the solenoid valve 70.

Although opening the thermostatic valve 42 to create velocity may tend to lower the pressure of the condensate delivered to the condensate pump 35, the valve opens only intermittently so that such tendency to drop pressure can occur only intermittently.

A special advantage of this adjustable arrangement for breaking the make-up water flow into pulses is that the rate at which new water is supplied and deaerated may be more or less independent of the action of the boiler feed pump 67. For example, the boiler feed pump 67 may, in a given installation, operate for five minutes and then remain idle for twenty minutes. During the five minutes of pump operation the water level of the reserve body of make-up water 66 in the tank 10 will drop several inches. During the five intervening minutes in which the pump is idle the solenoid valve 70 will release pulses of water into the receiver to restore the water level.

The timer 72 may, if desired, be so adjusted that the time taken for the water level to be restored from a drop of certain height in the tank 10 will be longer if the pressure in the solenoid valve 70 becomes lower than a predetermined value. This prevents the formation of steam in the return line of the system. The pressure pulsation in the steam lines causes a flashing action because each time the pressure drops slightly, a portion of every particle of water in the steam chest flashes into steam. There are countless water particles in and near the gas films and at the gas line pressure the condensate forms a thin condensate that flashes into steam increases in volume over 240 times. As a result, each particle of water becomes an explosive center of turbulence to disrupt the gas films and to promote heat transfer to the material in process. The gases torn away from the gas films are swiftly picked up by the velocity surges and swept into and through the return line of the system. The velocity surges also sweep conden-
state out of the steam chests continuously and keep the condensate films exceedingly thin. Only high temperature water reaches the boiler through the pump 35 is not permitted to drop to atmospheric pressure and because all new water added to the system is efficient. In a system using steam at 100 lbs. per square inch, the condensate passed through the pump 35 is maintained well above 300°F.

The new water is heated in four stages and then is intermixed with the high temperature condensate in the boiler feed line 17. The first stage of heating the new water is in the vent condenser 53; the next two stages are in the two-stage heater 40; and the fourth stage is accomplished by the coils 68 in the combined heat exchanger and separator 31. As a result, the temperature of the make-up water as it leaves the coils 68 is nearly 300°F.

It is apparent that the arrangement shown in Fig. 2 supplements the velocity-creating effect of the make-up water in several ways. In the first place, the relatively cool water or condensate supplied through the pipe 14 supplements the cooling effect of the make-up water on the thermostat 43. In the second place, because the tank 10 is under pressure the cooling effect of the vent condenser 53 reduces the pressure and temperature inside the tank with consequent cooling action on the thermostat 43. In the third place, the continuous removal of condensate by the pump 35 from the lower end of the separator 31 creates flow in the return line 18. In the fourth place, the condensing of steam in the separator 31 by the cooling effect of the water coil 68 and/or the cooling effect of water introduced by the spray head 104 serve to promote flow by contraction of the fluid mixture at the end of the return line.

All of these factors working together create and maintain whatever flow velocity is desired in any particular steam system, independently of the make-up water demand of the system and regardless of how small the make-up water demand may be. This arrangement, moreover, causes all heat units of the acceleration steam to be recharged and makes it unnecessary for acceleration steam to be wasted.

In various practices of the invention with the described apparatus, various parts may be taken out of operation if desired. Thus, as already noted, the condensate pump 35 may be cut off so that all the fluid from the return line 18 passes through the thermostat valve 42 into the tank 10. To change over to this mode of operation it is necessary merely to close the valve 37 to cut off the condensate pump 35 and to raise the temperature settings of the thermostat valve 42. When the master control unit is operated in this manner it does not return condensate directly to the boiler under pressure but does recirculate all of the condensate through the deaeration process to eliminate any air that may be picked up by the condensate.

It is obvious also that the circulating pump 130 may be kept out of operation in those instances in which the cooling effect of the make-up water alone on the thermostat 43 is sufficient to keep the system operating at high efficiency.

The instrument panel

In the preferred form of the invention the panel board 13 is provided with the following instrument panel.

A dial 87 indicates the deaeration temperature and a dial 88 indicates the deaeration pressure, both valves being taken near the thermostat bulb 43 where the fluid under pressure flows into the spray head 41. A dial 89 shows the return line pressure near the point at which the return line 18 connects with the combined heat exchanger and separator 31. A dial 90 shows the temperature of the feed water delivered to the boiler through the feed line 17 and a dial 91 shows the pressure of the make-up water supply taken near the connection of the water supply pipe 15 with the unit. A dial 92 indicates the pressure prevailing inside the master control tank 10. A signal lamp 95 is responsive to the mercury switch 16 to indicate the periods in which the system is taking in new water, and a second signal lamp 96 responds to energization of the solenoid valve 70 to indicate the occurrence of water pulses into the two-stage heater 40.

Tuning the unit to suit a particular steam system

A feature of the invention is that it incorporates a number of elements that may be changed or adjusted to cause the system to match precisely the requirements of any steam system within a very wide range. As a result, the control unit is extremely flexible and is not only readily adaptable to the requirements of any particular system but is also adaptable to changes in a steam system such as the addition of new heating equipment.

Any of the following adjustments may be made to vary the operation and control characteristics of the unit:

1. The temperature adjustment 45 of the thermostat valve 42 may be varied.
2. The rate of supply of the new water may be varied to change the cooling effect of the new water on the bulb 43. For example, the float valve 92 may be restricted or limited in its opening action to any degree desired.
3. The closing action of the thermostat valve 42 as well as the opening action may be limited to any degree desired.
4. The discharge capacity of the spray head 41 may be varied to vary the manner and degree of pressure rise in the spray head 41.
5. The prevailing pressure in the master control tank 10 may be raised or lowered.
6. The proportion of make-up water diverted to the spray head 104 in the separator 31 may be varied by manipulation of the valves 105 and 106.
7. The duration of the water pulses controlled by the solenoid valve 70, as well as the water pulses generated by the circulating pump 130, may be varied by adjustment of the timer 73.
8. The proportion of the water recirculated past the thermostat 43 by the pump 130 may be varied by adjustment of the two valves 134 and 135.
9. The temperature of the water recirculated by the pump 130 may be varied by varying either the temperature or rate of flow of the cooling medium employed in the heat exchanger 137.

Description of Fig. 3

The arrangement illustrated in Fig. 3 is largely similar to the previously described arrangement in Fig. 2 as indicated by the use of corresponding numerals to indicate corresponding parts.

One respect in which Fig. 3 differs from Fig. 2 is in the omission of the circulating pump 130, but it is to be understood that the circulating
pump may be added, if desired, in any particular installation.

The purpose of Fig. 3 is to illustrate how cooling water from the steam system apart from the master control unit may be introduced into the master control unit to supplement the cooling effect of the make-up water on the thermostat 43. For this purpose Fig. 3 shows pipe 14 connected to the pipe 55. The pipe 14 may bring cooling fluid to the unit from various sources of cooling water in various practices of the invention. In the present arrangement the cooling water is condensate supplied by a piece of steam using equipment 112 that operates on low-pressure steam. Fig. 3 shows a supply pipe 113 from the steam header 28 to the piece of equipment 112, this supply pipe being provided with a suitable pressure reducing valve 115. The return pipe 116 from the piece of equipment 112 may be provided with a suitable restriction 117 and is connected to the coil 118 of a heat exchanger 119. The other end of the coil 118 is connected to the pipe 14.

The heat exchanger 119 has an inflow pipe 120 and an outflow pipe 121 to permit any suitable cooling fluid to be recirculated for continuously cooling the condensate flowing through the coil 118.

Preferably the flow of the fluid supplied by the pipe 14 is broken into pulses and preferably such pulses are synchronized with the pulses of water created by the solenoid valve 70. To this end the pipe 14 is provided with a solenoid valve 142 and the solenoid valve 142 is energized by a pair of wires 143 that are connected in parallel with the previously mentioned solenoid valve 70. By virtue of this arrangement cooling water flows to the master control unit through the pipe 14 to supplement the cooling effect of the make-up water on the thermostat 43 and the pulses of water from both sources occur more or less simultaneously.

Our description in detail of preferred practices of the invention for the purposes of disclosure and to illustrate the principles involved is intended to suggest to those skilled in the art changes and substitutions under our basic concepts. We reserve the right to all such departures from our disclosure that fall within the scope of our appended claims.

We claim as our invention:

1. In a steam system of the character described having a steam source, at least one steam-using device and a return line, the combination there-of with means to promote flow velocity through the system, said flow-promoting means including: a valve to release fluid from said return line into a region of substantially lower pressure, a thermostat for causing opening operation of said valve in response to temperature below a given temperature and closing operation of the valve in response to temperature above said given temperature, said thermostat being positioned to be heated by the fluid discharge of the valve, means to flow relatively cool condensate from said system into heat-exchange relation with said thermostat for opening action of said valve, and automatic means to break said flow into short flow periods for intermittent operation of the valve to promote pulsations in the steam system.

2. In a steam system as set forth in claim 1, in which the flow of said condensate is controlled by a valve and an automatic control continually opens and closes said valve to break up the flow of the condensate.

3. In a steam system, a combination as set forth in claim 1, which includes a valve for controlling the flow of said condensate and an automatic timer controlling the operation of said condensate valve, said timer operating said condensate valve periodically and being adjustable with respect to such periodic action.

4. In a steam system of the character described having a steam source, at least one steam using device and a return line, the combination there-of with means to promote flow velocity through the system, said flow-promoting means including: a valve to release fluid from said return line into a region of substantially lower pressure, a thermostat for causing opening operation of said valve in response to temperature below a given temperature and closing operation of the valve in response to temperature above said given temperature, said thermostat being positioned to be heated by the fluid discharge of the valve, a first means effective to provide a stream of make-up water to cool said thermostat in response to demand for make-up water by the system, and a second means to automatically reduce the flow of said stream intermittently when said first means is effective.

5. In a steam system, a combination as set forth in claim 1 which includes a heat exchanger to reduce the temperature of said condensate before the condensate reaches said thermostat.

6. In a steam system, at least one steam-using device, a steam source connected therewith, a receiver, a return line conducting condensate from said device to said receiver, a valve controlling flow through said return line, a thermostat controlling said valve, means to direct the fluid released by the valve into heat-exchange relation with said thermostat to transfer heat thereto from the released fluid thereby to cause closing action by the valve, means to recycle the condensate from said receiver into heat-exchange relation with said thermostat thereby to cool the thermostat when said fluid is not being released by the valve and to modify the heating effect of the released fluid on the thermostat when the valve is open, means to continually vary the rate of flow of the recycled condensate.

7. In a steam system, at least one steam-using device, a steam supply connected with said device, a return line in open communication with said supply through said device, a valve to release fluid from said return line to promote flow in said device, boiler feed means to convey condensate under pressure direct from said return line, a thermostat operatively connected with said valve for closing action of the valve in response to temperature above its setting and opening action of the valve in response to temperature below its setting, said thermostat being positioned to be heated by the discharge from said valve, means to cool said thermostat with a stream of new water flowing in response to the demand of the system for make-up water, means to cool said thermostat additionally with a stream of condensate fluid independent of the demand of the system for make-up water, and automatic means to break up at least one of said streams of cooling fluid into short flow periods to create pulsations in the steam system.

8. In a steam system of the character described having a steam source, at least one steam-using device and a return line, the combination there-of with means to promote flow velocity through the system, said flow-promoting means includ-
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ing: a valve to release fluid from said return line into a region of substantially lower pressure, a thermostat for causing opening operation of said valve in response to temperature below a given temperature and closing operation of the valve in response to temperature above said given temperature, said thermostat being positioned to be heated by the fluid discharge of the valve, a means to direct make-up water into heat-exchange relation with said thermostat to cause opening action of said valve, a heat exchanger included in said return line, said heat exchanger having a passage for heating, water, and means to direct make-up water in a pulsating manner into heat-exchange relation with said bulb for cooling action on the bulb and subsequently to direct the make-up water through said passage for flow-promoting condensation in said return line.

9. In a steam system of the character described having a steam source, at least one steam-using device and a return line, the combination therewith of: a heat exchanger included in said return line, said heat exchanger having a passage for heating, water, and means to direct make-up water in a pulsating manner into heat-exchange relation with said bulb for cooling action on the bulb and subsequently to direct the make-up water through said passage for flow-promoting condensation in said return line.

10. In a steam system, at least one steam-using device, a steam supply connected with said device, a return line in open communication with said supply through said device, a receiver connected with said return line, said receiver containing a supply of make-up water for the system, a valve to release fluid from said return line into said receiver to promote flow in the return line, a thermostat operatively connected with said valve for closing action of the valve in response to temperature above its setting and opening action of the valve in response to temperature below its setting, said thermostat being positioned to be heated by the discharge from said valve, means to cool said thermostat with fluid to further promote flow in the valve for promoting flow, and automatic means to break up the flow of said cooling fluid into periodic flow intervals.

12. In a steam system of the character described having a steam source, at least one steam-using device and a return line, the combination therewith of means to promote flow velocity through the system, said flow-promoting means including: a valve to release fluid from said return line into the region of substantially lower pressure for promoting flow in the steam system, means to bring cooling fluid into heat-exchange relation with the contents of said return line for causing condensation of steam therein for further promotion of flow in the steam system, a thermostat for causing opening operation of the valve in response to temperature below said given temperature and closing operation of the valve in response to temperature above said given temperature, said thermostat being positioned to be heated by the fluid discharged from the valve, means to cool said thermostat with water independently of the make-up water demand of the system to increase the opening action of said valve, and means to break up the flow of said cooling fluid into periodic flow intervals.

13. In a steam system of the character described having a steam source, at least one steam-using device and a return line, the combination therewith of means to promote flow velocity through the system, said flow-promoting means including: means to bring cooling fluid into heat-exchange relation with the contents of said return line for causing condensation of steam therein to set up a pressure differential across the system for promotion of flow in the system, a condensate pump for returning condensate to said boiler, said condensate pump having its intake port in a communication with said return line to remove condensate therefrom for further promotion of flow in the system, a valve to release fluid from said return line into a region of substantially lower pressure than the return line to set up a still further pressure differential across the system for further promotion of flow in the steam system, a thermostat controlling said valve, said thermostat being positioned for rise in temperature by heat supplied by said return line, means to cool said thermostat with fluid to modify the operation of said valve, said fluid being, at least in part, condensate from the system, and means to break up the flow of said cooling fluid into periodic flow intervals.

14. In a clear channel steam system of the character described, in which steam is continually released from the return line of the system to create flow velocity in the system, the combination therewith of: means to employ the released steam for preheating make-up water, means to cause make-up water to flow into said preheating means, and means during periods in which the steam system demands make-up water to break up said flow of make-up water into periodic increments thereby to spread the make-up water demand over the major portion of the operating time of the system.

15. In a clear channel steam system, a combination as set forth in claim 14, which includes
means to vary said increments for different magnitudes of make-up water demand.

16. In a clear channel steam system, a combination as set forth in claim 15, in which said varying means includes a timer continually repeating a given cycle, said timer being adjustable with respect to the quantity of make-up water flowing in each cycle.

17. In a method of operating a clear channel steam system of the character described, in which steam is continually released from the return end of the system to create flow velocity in the system and is used to preheat make-up water for the system, the improvement that comprises breaking up the supply of make-up water into periodic increments when the system demands make-up water, thereby spreading the make-up water demand over the major portion of the operating time of the system, and releasing the steam in a corresponding series of increments to preheat the water increments.

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