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H. H. GORRIE

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APPARATUS FOR DESUPERHEATING VAPOR

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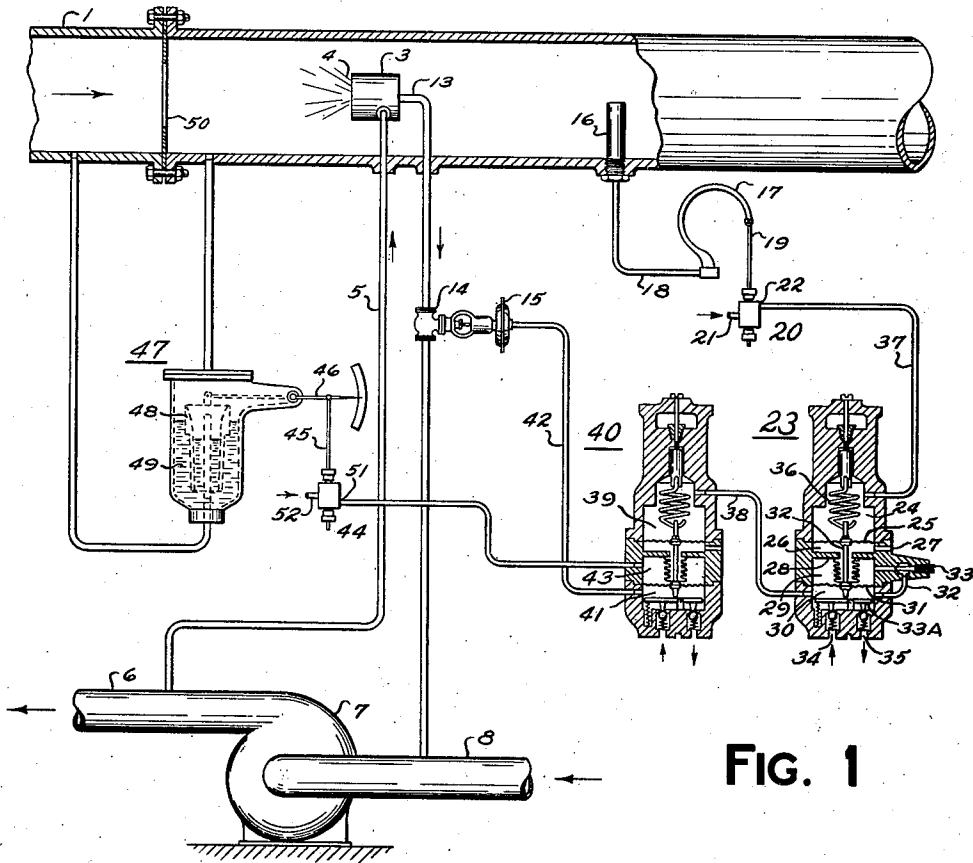


FIG. 1

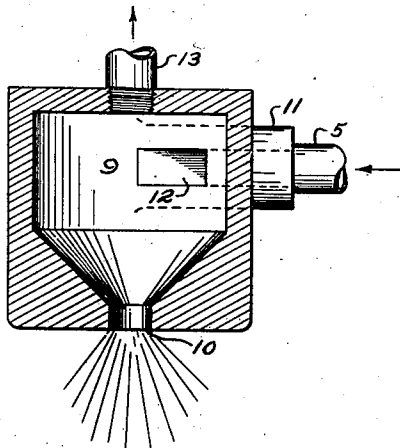


FIG. 3

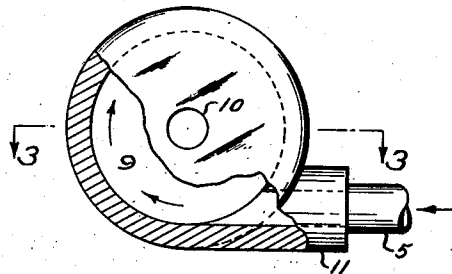


FIG. 2

INVENTOR
HARVARD H. GORRIE
BY *Raymond H. Jenkins*
ATTORNEY

UNITED STATES PATENT OFFICE

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APPARATUS FOR DESUPERHEATING VAPOR

Harvard H. Gorrie, Cleveland Heights, Ohio, assignor to Bailey Meter Company, a corporation of Delaware

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9 Claims. (Cl. 122-479)

This invention relates to apparatus for partially or completely desuperheating vapor.

It is well known to desuperheat a flowing stream of vapor, such as steam for example, by providing a spray ring or nozzle having a plurality of fine openings through which water flows in an atomized or broken up condition into the steam. Such a system is satisfactory when the pressure drop across the fine openings corresponds to that for which they were designed. However, if used on a variable steam flow, necessitating throttling of the water supply in order to maintain a constant temperature of the desuperheated steam, the arrangement is not satisfactory as the water then is not atomized or broken up but leaves the openings in a solid stream so that intimate mixing with the steam is not obtained. It has been found in commercial practice that a desuperheater designed to properly desuperheat a given maximum steam flow will not operate satisfactorily if the steam flow is reduced below 50% of the said maximum.

It is therefore one object of my invention to provide apparatus for desuperheating vapor whereby a finely atomized spray is obtained over a wide range in output.

Further, in accordance with my invention changes in the temperature of the desuperheated vapor are anticipated and the output of the desuperheater modified accordingly before such changes in temperature actually occur.

My invention further provides for controlling the output of a desuperheater conjointly from the temperature of the desuperheated vapor and the rate of flow thereof.

My invention further provides for varying the output of a desuperheater, both proportionately to changes in the temperature of the desuperheated vapor and to the amount of deviation of the temperature from a predetermined or desired magnitude.

It should be understood that the term "desuperheated vapor" or "desuperheated steam" as used in this specification applies to vapor or steam which may be only partially desuperheated and not necessarily to zero degrees of superheat.

In the drawing:

Fig. 1 illustrates diagrammatically an embodiment of my invention.

Fig. 2 is an elevation view to larger scale of the spray nozzle shown in Fig. 1.

Fig. 3 is a cross sectional view of the spray nozzle along the lines 3-3 of Fig. 2 in the direction of the arrows.

In accordance with the present invention there

is provided a conduit 1 to which superheated vapor is admitted so that it flows through the conduit in the direction indicated by the arrow.

Extending into the conduit is a water jet or spray nozzle 3 pointing upstream with respect to its discharge end 4, although the direction of discharge may be reversed if desired. Water is supplied the nozzle 3 under a pressure greater than that of the vapor to be desuperheated, through a pipe 5 leading from any suitable source, such as the discharge conduit 6 of a centrifugal pump 7 to which water is admitted through an inlet 8. It will be understood that the arrangement I have shown for providing desuperheating fluid to the nozzle 3 is merely illustrative and that any suitable source may be used.

The nozzle 3 as shown in Figs. 2 and 3 comprises a circular chamber 9 provided with an axially located aperture or orifice 10 through which the desuperheating fluid, such as water, is discharged into the stream of vapor to be desuperheated. Water is admitted to the chamber 9 from the pipe 5 through an inlet connection 11 and port 12 tangentially with respect to the circular wall of the chamber 9. Water entering the chamber 9 and not discharged through the orifice 10 is withdrawn through an axially located secondary outlet connection 13 leading to a source of relatively low pressure, which may be for example the inlet 8 of the pump 7.

The port 12 is arranged so that water passes therethrough at high velocity and sets up in the chamber 9 a rapid rotary motion which causes the water to be discharged through the orifice 10 in the form of a spray or finely atomized condition. The rate of discharge through the orifice 10 may be varied by throttling the flow through the secondary connection 13. With the secondary connection closed, all the water admitted through the port 12 is discharged through the orifice 10. With the secondary connection partially restricted some of the water will be discharged therethrough, decreasing the discharge through the orifice 10 proportionately. Variations in the rate of discharge through the secondary connection 13 does not, however, affect the velocity through the tangential port 12 or the rapidity of the rotary motion set up in the chamber 9. Inasmuch as the quality of the spray produced by the orifice 10 depends substantially entirely upon the rate of rotation of the mass of water within the chamber 9 it follows that variations in the discharge through the secondary outlet 13 and corresponding variations in the discharge to the orifice 10 will in no way affect the

quality of the spray established. In other words, the fineness or quality of the spray is determined by the rotary motion of the water within the chamber 9, which remains substantially constant at all times, whereas the rate of discharge into the conduit 1 is determined by the pressure drop across the orifice 10, which in turn is controlled by the throttling of the secondary outlet 13. I have found that the water will leave the nozzle 3 efficiently atomized, from a maximum flow obtained with the secondary outlet 13 closed down to approximately 10% or less of that maximum.

It is apparent from the foregoing that the temperature of the desuperheated steam may be held at some predetermined desired value regardless of changes in the rate of flow thereof by varying the flow through the secondary outlet in accordance with deviations in the temperature from the predetermined or desired value. It is further apparent that the throttling of the flow through the secondary outlet will have no effect upon the efficient atomizing of the water spray, so that the steam will be uniformly desuperheated to the predetermined or desired temperature.

In Fig. 1 I show a valve 14 connected in the secondary outlet 13 for throttling the flow there-through. The valve 14 is arranged to be actuated by a pressure sensitive diaphragm motor 15. As shown, upon an increase in fluid pressure of given amount the diaphragm motor acts to position the valve 14 in a closing direction a proportionate amount. Conversely, upon a decrease in fluid pressure the diaphragm motor acts to position the valve a proportionate amount in an opening direction.

In one particular aspect my invention contemplates establishing a fluid pressure varying both in accordance with changes in temperature of the desuperheated steam and the amount of deviation of the actual temperature from the desired or predetermined temperature, and utilizing the fluid pressure to position the diaphragm motor 15. Accordingly, upon a change in temperature of the desuperheated steam, regardless of whether the change is toward or away from the predetermined value, an immediate and proportionate change is made in the flow through the secondary outlet 13 in a sense to produce a temperature change of the desuperheated steam in opposite direction. Continuously, however, the flow through the secondary outlet 13 is modified at a rate proportional to the amount of deviation of the desuperheated steam temperature from the predetermined value so that the temperature is maintained substantially at the predetermined value without overshooting or hunting, regardless of changes in the rate of flow of steam to be desuperheated or changes in the degree of superheat thereof.

I will now describe the apparatus provided for producing the fluid pressure for actuating the diaphragm motor 15. The temperature of the desuperheated steam is measured by a thermometric system comprising a bulb 16 extending into the conduit 1 beyond the nozzle 3 and connected to a Bourdon tube 17 by a capillary 18. An increase in temperature of the desuperheated steam effects a proportionate movement of the free end of the Bourdon tube 17 in an upward direction. Conversely, a decrease in superheated steam temperature effects a proportionate positioning of the Bourdon tube in a downward direction.

Pivotaly connected to the free end of the Bourdon tube 17 is the movable valve member 19 of a pilot valve 20 preferably of the type forming the subject matter of a United States patent to Clarence Johnson, Patent No. 2,054,464, dated September 15, 1936. Suitable fluid under pressure, such as compressed air, is admitted to the pilot through an inlet port 21 and is conducted to waste ports at either end of the pilot valve through an axially located cylindrical passage-way extending longitudinally through the pilot valve. Vertical positioning of the valve member 19, which carries suitable lands, modifies the magnitude of the fluid pressure effective at an outlet port 22 so that for every position of the valve member there is a pressure of definite magnitude, which for convenience I term a loading pressure, established at the outlet port. With the valve member 19 at the lowest position within its range of movement a loading pressure of minimum magnitude is established at the outlet port. With the valve member at the highest position within its operating range a loading pressure of maximum magnitude is established. Between these two extremes the loading pressure will vary proportionately with the axial positioning of the valve member.

Variations in loading pressure established at the outlet port 22 are effective for actuating the diaphragm motor 15 to cause proportionate movements of the valve 14. Accordingly, upon an increase in the temperature of the desuperheated steam the valve member 19, through the agency of the Bourdon tube 17, will be positioned upwardly a proportionate amount effecting a like change in the loading pressure at the outlet port 22. This change in loading pressure transmitted to the diaphragm motor 15 through devices later to be described actuate the motor to position the valve 14 in a closing direction an amount proportional to the increase in desuperheated steam temperature. A greater proportion of the water transmitted to the nozzle 3 will then be discharged through the orifice 10 tending to restore the temperature of the desuperheated steam to the desired value. If now the temperature of the desuperheated steam should decrease, the loading pressure transmitted to the diaphragm motor 15 will decrease proportionately, effecting a movement of the valve 14 in an opening direction, thus decreasing the discharge of water into the conduit 1. It is apparent that the apparatus so far described will act to maintain a definite rate of discharge of water for every temperature of the desuperheated steam.

To provide an ample supply of pressure fluid for operating the diaphragm motor 15 and further to provide means for producing a continuous change in the rate of flow through the secondary outlet 13 at a rate proportional to the amount of deviation of the actual value of the desuperheated steam temperature from the predetermined value I preferably interpose between the outlet port 22 and the diaphragm motor 15 a standardizing relay 23 of the type forming the subject matter of my copending application, Serial No. 8047, filed in the United States Patent Office February 25, 1935.

Within the relay 23, which is shown in cross section, is a chamber 24 separated by a pressure sensitive diaphragm 25 from a chamber 26 open to the atmosphere through a port 27. Below a pressure tight partition 28 is a further pair of chambers 29 and 30 separated by a pressure sen-

sitive diaphragm 31, and connected with each other through a passageway 32 in which is located an adjustable throttling valve 33 for controlling the rate at which pressure fluid will bleed from one chamber to the other. Secured to the diaphragms 25 and 31 is a movable member 32 engaging at its lower end a fulcrumed normally horizontal member 33A carrying depending extensions for operating a normally closed pressure fluid admission valve 34 when displaced from the horizontal in one direction, and a normally closed pressure fluid exhaust valve 35 when displaced in the opposite direction. The pressure fluid, such as compressed air, admitted through the valve 34 may be derived from any suitable source (not shown). Secured to the upper end of the movable member 32 is a manually adjustable tension spring 36 for urging the member 32 upwardly.

The outlet port 22 of the pilot 20 is connected to the chamber 24 through a pipe 37 so that loading pressures established by the pilot valve are immediately effective therein and produce a proportionate downwardly acting force on the diaphragm 25.

Now assuming for the moment that the throttling valve 33 is closed, the force acting against the diaphragm 25 will position the member 32 downwardly opening the admission valve 34 and permitting the pressure fluid to enter chamber 30. As the pressure within the chamber 30 increases the force acting upwardly against the diaphragm 31 will increase, and when it is equal to or stands in predetermined relation to the force acting on the diaphragm 25 the member 32 will move upwardly closing the admission valve 34. Conversely, upon a decrease in pressure within the chamber 24 the member 32 will move upwardly opening the exhaust valve 35, permitting pressure fluid to escape from the chamber 30 until the force acting upwardly on the diaphragm 31 is again equal to that acting downwardly on the diaphragm 25. Thus for every pressure within the chamber 24 there will be a corresponding pressure within the chamber 30. While a change in pressure of given amount within the chamber 24 will result in an equal change in pressure within chamber 30, the absolute value of the pressure within the chamber 30 may be different from that within chamber 24 and is controlled by the adjustment of the spring 36.

If now the throttling valve 33 is partially opened so that pressure fluid may pass at a relatively slow rate between chambers 29 and 30, upon a change in pressure within the chamber 24 a proportionate change will immediately occur in chamber 30. Thereafter, however, in place of the valves 34 and 35 remaining closed and the pressure within chamber 30 constant, pressure fluid will pass between the chambers destroying the equilibrium forces acting upon the diaphragms 25 and 31 and occasioning a further change in pressure within the chamber 30. Such further change will cause a further passing of fluid between the chambers 29 and 31 and result in a still further change in pressure within the chamber 30. While I have described the operation and steps, it is apparent that the change in pressures within the chambers 29 and 30 will be gradual and continuous.

In operation the spring 36 is initially adjusted so that with the loading pressure existing within the chamber 24 corresponding to that produced when the temperature of the desuperheated

steam is at the predetermined value, and the throttling valve 33 open so that equal pressures will exist in chambers 29 and 30, the valves 34 and 35 are closed. The throttling valve is then moved to a partially closed position, the exact position being determined by the constants of the system, such as speed of response, lag, etc. Thereafter upon a change in loading pressure within the chamber 24 an immediate and proportionate change will occur in chamber 30, which will be followed by a continuing secondary change due to the regenerative action between chambers 29 and 30 as hereinbefore described. It is apparent that the rate of the secondary change will be proportional to the difference in pressure between chambers 29 and 30, which will in turn be proportional to the deviations in temperature from the desired value. It is further apparent that only when the temperature is at the predetermined value will the pressure within the chamber 30 remain constant. When at any other value the pressure therein will continually change, and in sense dependent upon the direction of deviation of the temperature from the predetermined value.

The pressure within the chamber 30 is transmitted through a pipe 38 to a chamber 39 of an averaging relay 40 somewhat similar to the standardizing relay 23. Changes in pressure within the chamber 39 produce proportionate changes in pressure within the chamber 41 connected to the diaphragm motor 15 by a pipe 42.

In operation, assuming the desuperheated steam temperature to be at the predetermined value, upon a change in temperature of given amount, for example an increase, a proportionate change in loading pressure within the chamber 24 will occur which will produce an immediate and proportionate change in the pressure within the chamber 30, which will be transmitted through the relay 40 to the diaphragm motor 15. The diaphragm motor will operate the valve 14 in a closing direction to decrease the flow through the secondary outlet, thus increasing the discharge of water into the conduit 1. A pressure differential will now exist between chambers 29 and 30 so that the pressure within chamber 30 will continue to increase at a rate proportional to the temperature deviation and thus the valve 14 will continue to be positioned in a closing direction at a proportionate rate. As the temperature of the desuperheated steam returns toward the predetermined value the immediate response to such changes will be to open the valve 14, or in other words in a direction tending to prevent such return. However, the secondary continuing response will still act to close the valve so that the return of the temperature to the predetermined value will be asymptotically and overshooting or hunting will be avoided.

Upon a decrease in temperature below the desired value the converse action will occur, the valve 14 first being positioned in an opening direction an amount proportional to the decrease in temperature, and thereafter continuously positioned in an opening direction at a rate proportional to the amount the temperature is below the predetermined value. It is apparent that in general the control responds upon a change in temperature to give an immediate and proportionate correction in a direction to prevent the change, and to give a continuing correction in a direction to restore the temperature to the desired value. The first or immediate response is

of a relatively high speed but of small amount, whereas the secondary or continuing response is of a relatively large amount but slow speed.

The control so far described will under ordinary operating conditions give satisfactory results. It is to be noted, however, that it is necessary for a deviation in temperature of the desuperheated steam to occur before a correction is made to restore the temperature to the predetermined value. Under widely varying rates of steam flow resulting in sudden and extreme changes in desuperheated steam temperature the allowable limits of temperature deviation from the predetermined value may be exceeded. To prevent such an occurrence my invention further contemplates anticipating changes in temperature and correcting the rate of discharge of water into the superheated steam before such changes actually occur. In general, the control acts to vary the discharge through the orifice 10 in proportion to changes in steam flow. If due to valve or nozzle characteristics or other causes the change in water discharge so made is not exactly correct to maintain the desuperheated steam temperature at the predetermined value then the control sensitive to the temperature of the desuperheated steam will continually modify the water discharge until the predetermined temperature is restored.

To position the valve 14 to vary the rate of discharge through the orifice 10 in accordance with changes in steam flow I introduce into a chamber 43 of the averaging relay 40 a loading pressure proportional to the rate of steam flow. Thus upon an increase in steam flow, for example, the loading pressure within the chamber 43 is increased proportionately, causing a like increase in pressure within the chamber 41, which is transmitted to the diaphragm motor 15 and serves to position the valve 14 in a closing direction, thereby increasing the discharge of water into the conduit 1. Upon a decrease in the rate of steam flow the reverse action takes place, the loading pressure within the chamber 43 decreasing proportionately, causing a like movement of the valve 14 in an opening direction, thereby decreasing the rate of discharge of water through the orifice 10.

If correct correspondence has been maintained during and after such changes, between water discharge and rate of steam flow, and there has been no change in superheated steam temperature, then the desuperheated steam temperature will remain at the predetermined value. If, however, such correspondence is not exactly maintained, then a relatively small change in desuperheated steam temperature will occur, which will readily be corrected by the control sensitive to desuperheated steam temperature as hereinbefore described.

The loading pressure established within the chamber 43 and varying in accordance with changes in steam flow is produced by a pilot valve 44 having a valve member 45 vertically positioned by an indicator arm 46 of a rate of flow meter 47.

The flow meter 47 may be of the type shown and described in United States Patent 1,123,164 to Bailey, and comprises essentially a bell 48 sealed in a liquid such as mercury indicated at 49 and vertically positioned therein in accordance with the differential pressure produced by a restriction such as an orifice 50 in the conduit 1. As known, the differential pressure produced by a device such as the orifice 50 bears a quadratic relation to the rate of flow. In order that the in-

dicator arm 46 will be positioned directly proportional to changes in flow rather than differential pressure the bell 48 may be provided as shown with a wall of varying thickness, so that it will be positioned proportional to the square root of the differential pressure rather than in direct proportion.

The pilot valve 44 is similar to the pilot 20, inasmuch however as the loading pressure produced thereby should progressively increase as the valve member 45 moves downwardly, connection from the chamber 43 is made to an outlet port 51 located below the inlet port 52. Thus when the indicator arm 46 is in the highest, or no flow, position the loading pressure existing at the outlet port 51 will be at some predetermined minimum value, and when the indicator arm is at the lowest position the loading pressure will be at a maximum value.

While I have chosen to illustrate and describe a preferred embodiment of my invention, it will be understood that this is by way of illustration only, and that I am not to be limited thereby, but only as to the claims in view of prior art.

What I claim as new, and desire to secure by Letters Patent of the United States is:

1. A desuperheater comprising a chamber, an orifice of constant area located in said chamber for discharging desuperheating fluid directly into a flowing stream of vapor to be desuperheated, a discharge connection to said chamber for withdrawing desuperheating fluid therefrom, and means for controlling the rate of flow of fluid through said discharge connection conjointly responsive to the rate of flow of the vapor to be desuperheated and the temperature of the desuperheated vapor.

2. A desuperheater comprising a chamber, an orifice located in said chamber for discharging desuperheating fluid into a flowing stream of vapor to be desuperheated, a discharge connection to said chamber for withdrawing desuperheating fluid therefrom, regulating means of the rate of flow through said discharge connection, and control means for said regulating means comprising means for establishing a first fluid pressure in accordance with the temperature of the desuperheated vapor, means responsive to changes in said first fluid pressure for establishing immediate proportional changes in a second fluid pressure and continuing changes therein upon departure of the first fluid pressure from a predetermined value, and means actuated by said second fluid pressure for controlling said regulating means.

3. A desuperheater comprising a chamber, an orifice in a wall of said chamber for discharging desuperheating fluid into a flowing stream of the vapor to be desuperheated, a discharge connection to said chamber for withdrawing desuperheating fluid therefrom, means responsive to the temperature of the desuperheated vapor, and means actuated by said last named means for producing immediate changes in the rate of flow of fluid through said discharge connection in proportion to changes in the temperature of the desuperheated vapor and continuous changes proportional to the deviation of the temperature of the desuperheated vapor from a predetermined value.

4. A desuperheater comprising a chamber, an orifice in a wall of said chamber for discharging desuperheating fluid into a flowing stream of vapor to be desuperheated, a discharge connection to said chamber for withdrawing desuperheating fluid therefrom, means for producing a

first fluid pressure in accordance with the temperature of the desuperheated vapor, means for establishing a second fluid pressure in accordance with the rate of flow of the vapor to be desuperheated, means for establishing a third fluid pressure in accordance with the algebraic sum of the first and second fluid pressures, and regulating means of the rate of flow of fluid through said discharge connection under the control of said third fluid pressure.

5. A control system for a de-superheater comprising in combination, means for establishing a first fluid pressure in accordance with the rate of flow of vapor to the desuperheater, means for establishing a second fluid pressure in accordance with the temperature of the de-superheated vapor, means under the control of the first fluid pressure to regulate the rate of flow of the desuperheating fluid in direct ratio to the rate of flow of the vapor to be de-superheated, and means under the control of the second fluid pressure for varying the ratio between the rate of flow of vapor and desuperheating fluid.

6. In a control system for a desuperheater in combination, regulating means of the rate of flow of desuperheating fluid, control means for said regulating means comprising means for establishing a first fluid pressure in accordance with the temperature of the desuperheated vapor, means responsive to changes in said first fluid pressure for establishing immediate proportional changes in a second fluid pressure and continuing changes therein upon departure of the first fluid pressure from a predetermined value, and means actuated by said second fluid pressure for controlling said regulating means.

7. In a control system for a desuperheater, wherein a desuperheating fluid is used to desuper-

heat a flowing fluid to be desuperheated, in combination, means for establishing a first fluid pressure corresponding to the temperature of the desuperheated vapor, means for establishing a second fluid pressure corresponding to the rate of flow of vapor to be desuperheated, means for establishing a third fluid pressure corresponding to the algebraic sum of the first and second fluid pressures, and regulating means of the desuperheating fluid actuated by the third fluid pressure.

8. In a control system for a desuperheater wherein a desuperheating fluid is used to desuperheat a flowing fluid to be desuperheated, in combination, means for establishing a first fluid pressure corresponding to the temperature of the desuperheated vapor, means for establishing a second fluid pressure corresponding to the rate of flow of desuperheating fluid, means under the control of the first fluid pressure for producing changes in the second fluid pressure proportional to changes in the first fluid pressure, and regulating means of the desuperheating fluid actuated by the second fluid pressure.

9. In a control system for a desuperheater wherein a desuperheating fluid is used to desuperheat a flowing fluid to be desuperheated, in combination, regulating means of the rate of flow of the desuperheating fluid comprising means for establishing immediate and proportional changes in a fluid pressure in accordance with changes in the temperature of the desuperheated vapor and continuing changes in the fluid pressure in accordance with the departure of the temperature of the desuperheated vapor from a predetermined value, and regulating means of the desuperheating fluid under the control of said fluid pressure.

HARVARD H. GORRIE.