

April 25, 1939.

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2,155,986

DESUPERHEATER

Filed June 24, 1937

2 Sheets-Sheet 1

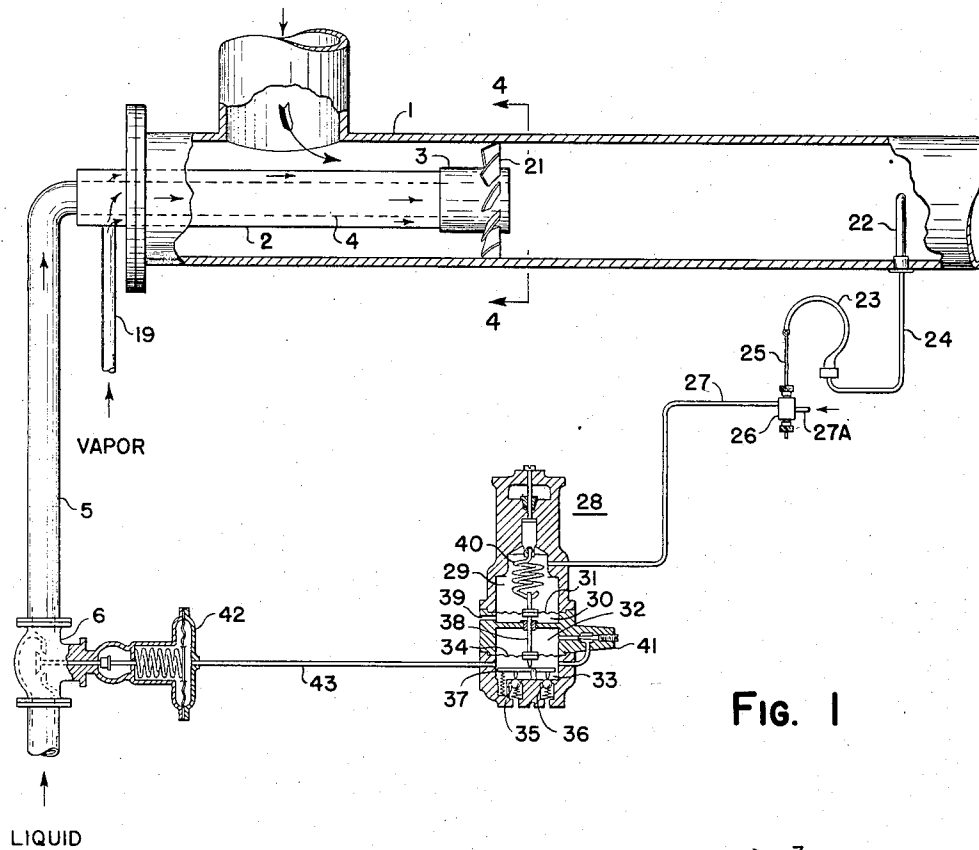


FIG. 1

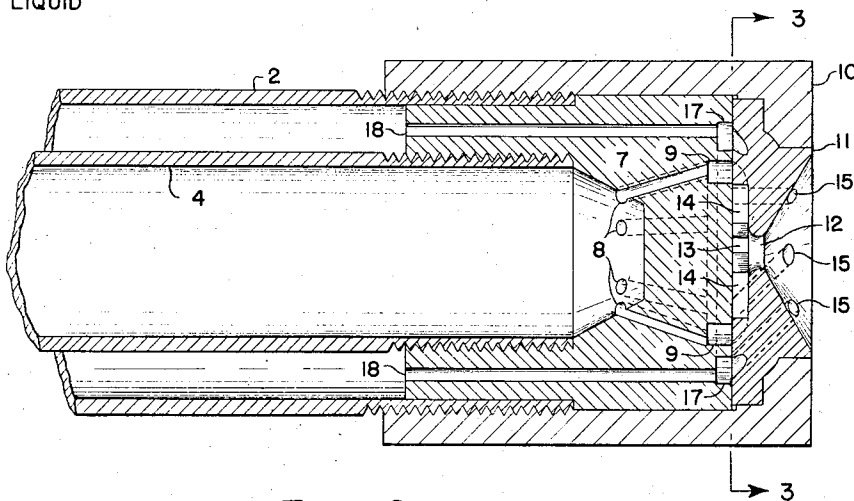


FIG. 2

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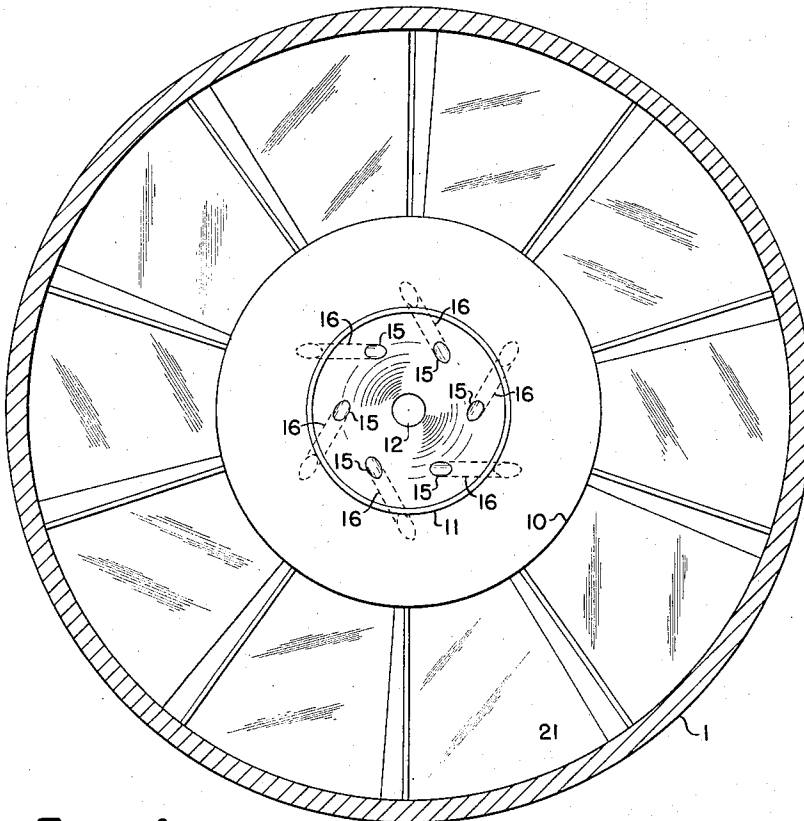


FIG. 4

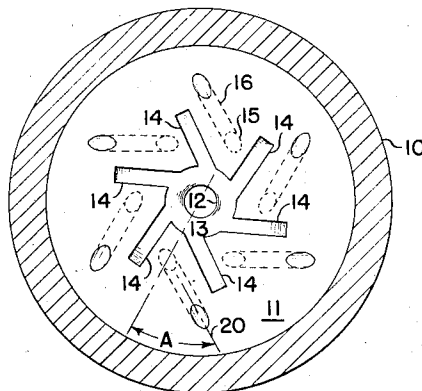


FIG. 3

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2,155,986

DESUPERHEATER

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9 Claims. (Cl. 261—116)

This invention relates to a desuperheater 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 through which water flows in a more or less atomized or broken-up condition into the stream of flowing vapor. Such a system is satisfactory when the pressure drop across the spray ring or nozzle corresponds to that for which it was designed. However, if used on a variable flow, necessitating throttling of the supply of desuperheating fluid in order to maintain a constant temperature of the desuperheated vapor, the arrangement is not satisfactory, as the fluid then is not atomized or broken up but leaves the ring or nozzle in a more or less solid stream so that intimate mixing with the vapor is not obtained. It has been found in commercial practice that a desuperheater designed to properly desuperheat a given maximum vapor flow will not operate satisfactorily if the flow is reduced below about 50% of the said maximum.

It is therefore one object of my invention to provide a desuperheater wherein the desuperheating fluid is maintained in suspension in a finely atomized condition until vaporized regardless of the rate of vapor flow.

It is a further object of my invention to provide apparatus stable in operation, economically constructed and readily installed.

Still another object of my invention is to provide apparatus for controlling the rate of flow of desuperheating fluid to the desuperheater so that a constant vapor temperature at the outlet of the desuperheater is maintained regardless of changes in the rate of flow of vapor past the desuperheater.

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 unless a specific statement is made indicating that partial or complete desuperheated vapor is intended.

In the drawings:

Fig. 1 is a diagrammatic illustration of a desuperheater embodying my invention.

Fig. 2 is a cross sectional view to larger scale of the discharge nozzle assembly shown in Fig. 1.

Fig. 3 is an end view of the discharge nozzle assembly shown in Fig. 2 along the line 3—3 in the direction of the arrows.

Fig. 4 is a view to larger scale along the line 4—4 of Fig. 1 in the direction of the arrows.

In accordance with the present invention there is provided a conduit 1 through which a superheated vapor such as steam flows in the directions indicated by the arrow. Extending into the conduit 1 is a tube 2 carrying at its end a discharge nozzle assembly generally indicated at 3. Desuperheating fluid is discharged from the nozzle 3 in the form of a hollow cone, and is vaporized by the vapor to be desuperheated. As shown in Fig. 1 the discharge nozzle 3 points down stream. However, the direction of discharge may be reversed if desired.

Desuperheating fluid such as water is supplied the nozzle 3 through an inner tube 4 within the tube 2, connecting to a pipe 5 leading from any suitable source of supply (not shown). Located in the pipe 5 is a valve 6 for regulating the rate of flow of water to the desuperheater.

As shown in Fig. 2, threaded to the end of inner tube 4 is a block 7 in which are passageways 8 for conducting water to an annular channel 9 cut in the outer surface of the block. A plurality of passageways 8 are provided to give a uniform flow of water to the annular channel 9.

Held against the outer surface of the block 7 by a shrouding ring 10 is a nozzle tip 11 having an axially located port or orifice 12 through which water is discharged into the vapor to be desuperheated. On the inlet side of the orifice 12 is a circular chamber 13 to which water is supplied through a plurality of tangential passageways 14, as shown more clearly in Fig. 3. The annular channel 9 is located so that the outer ends of the passageways 14 communicate therewith. Accordingly, water flows from the inner tube 4 through the passageways 8 to the annular space 9 and thence through the passageways 14 to the cylindrical chamber 13, whence it is discharged into the conduit 1 through orifice 12.

The tangential arrangement of the passageways 14 imparts to the water upon entering the chamber 13 a rapid rotary or whirling motion, which causes the water to be discharged tangentially through the orifice 12 in the form of a hollow conical spray. To further impart to the water a desired conical shape I show the outer face of the nozzle tip 11 dished, the angle of divergence of which may be varied in accordance with the conditions to be met in any particular installation. Thus under some conditions I may find it advisable to have the outer

face substantially flat, and under other conditions to have a sharp angle of divergence. The rate at which water is discharged through the orifice 12 may be varied by means of the regulating valve 6 to maintain a desired temperature of the desuperheated vapor.

Under normal operating conditions the rotary motion of the water set up in the chamber 13 is sufficient to eject the water in a well defined conical shape. Under the condition, however, of relatively low rates of steam flow, when a relatively small amount of water is required to maintain a desired temperature of the desuperheated steam, the water will not be discharged through the orifice 12 in this condition, but will be ejected therefrom in a more or less solid stream having a tendency to trickle down the dished face of the nozzle tip 11. Before the discharged water has an opportunity of becoming intimately mixed with the superheated steam, it is thrown against the inner wall of the conduit 1 or is carried down the conduit in the form of solid drops of water. This condition is undesirable in that a non-uniform temperature of the desuperheated vapor results and furthermore the water may be carried over into a vapor consuming apparatus, such as a steam turbine, and occasion considerable damage to the working parts thereof. To avoid this condition I provide means for finely atomizing the water regardless of the rate of discharge and for maintaining the water in the desired conical shape so that ample time is available for the water to become intimately mixed and vaporized by the steam to be desuperheated.

Referring to Fig. 4, there are arranged circumferentially about the discharge orifice 12 a plurality of ports or nozzles 15, communicating by means of passageways 16 to an annular space 17 (shown in Fig. 2) in the outer face of the block 7. The annular space 17 communicates by means of passageways 18 with the annular space formed by the tube 2 and inner tube 4. As shown in Fig. 1, this annular space is connected to a pipe 19 leading to a suitable source of steam (not shown) under a higher pressure than that of the steam within the conduit 1. Steam passing through the pipe 19 is discharged through the ports 15 under a relatively high velocity, and upon striking the water discharged from the orifice 12 shatters it into a finely divided state.

The passageways 16 pass obliquely through the nozzle tip 11 so that a diverging cone is formed by the discharged steam. The angle of divergence of the cone so formed may be varied by changing the obliquity of the passageways 16. The obliquity necessary in any specific case to produce optimum results will depend upon the particular conditions incident to that case. In general, I may obtain any desired atomizing effect by varying the obliquity of the passageways 16.

In the embodiment of my invention illustrated, the passageways 16 are further illustrated as arranged so that the projections of their center lines to the plane of the passageways 14 are substantially parallel to the adjacent passageway as shown in Fig. 3. This in effect causes the discharged steam to form a cone enveloping the cone of water discharged through the orifice 12. It is apparent that by having the projected center lines form an angle with the passageways 14 the two cones may be caused to intersect at any desired distance from the outer face of the nozzle tip 11. To further illustrate I have shown in Fig. 3 the projected center line 20 of a passageway 16 form-

ing an angle A with a radial line passing through the discharge port of the passageway. With the angle A, as shown, the jet of steam issuing from the discharge port 15 does not materially interfere with the water issuing from the orifice 12 so long as the latter maintains a predetermined conical shape. However, if due to a low discharge rate through the orifice 12 the water discharges therefrom in a stream tending to trickle down the face of the nozzle tip 11, the steam issuing from the port 15 at a relatively high velocity will strike the water, breaking it up into a finely atomized condition and carry it in suspension for a sufficient length of time to become vaporized by the steam flowing through the conduit 1. By decreasing the angle A the interference between the steam issuing from the port 15 and the water issuing from the orifice 12 is increased, and when the angle A is reduced to zero the jets of steam issuing from the port 16 will meet at a point distant from the orifice 12, varying with the obliquity of the passageway 16 with respect to the longitudinal center line of the nozzle tip 11.

If the angle A is made negative, that is if the projected center line 20 lies on the opposite side of the radial line than shown, then a further turbulent action between the water and steam will be obtained, as the jets of steam will then be discharged in opposite direction to the general direction of discharge of the water through the orifice 12.

As stated, when the angle A is zero the jets of steam converge at a point beyond the orifice 12. The distance of the point of convergence from the orifice 12 may be varied by varying the angle of obliquity of the passageways 16. Thus if the passageways 16 pass through the nozzle tip 15 parallel to the axis thereof, it is apparent that the steam jets will be parallel with respect to each other and the point of convergence will lie at infinity. As the passageways 16 are made more oblique the point of convergence approaches the face of the orifice 12. It is apparent, therefore, that by varying the angle with which the passageways 16 pass through the orifice tip 11 I may produce any desired interference between the steam jets and the water discharging through the orifice 12.

To further promote intimate mixing between the steam passing through the conduit 1 and the water discharging through the orifice 12, I show arranged about the nozzle assembly 3 a plurality of blades 21 arranged obliquely with respect to the center line of the conduit 1. As shown in Figs. 1 and 4, the blades 21 are arranged to impart a circular motion to the steam in opposite direction to the general direction of the water issuing from the orifice 12. Accordingly, upon the steam meeting the water, a high relative velocity is maintained therebetween so that the particles of water are constantly in engagement with highly superheated steam. That is, a scrubbing action occurs between the particles of water and the particles of steam, tending to maintain the particles of water in suspension and to rapidly vaporize them.

In Fig. 1 I show the valve 6 arranged to be automatically positioned to regulate the rate at which water is discharged from the nozzle 3 to maintain a desired temperature of the desuperheated vapor. Therein I disclose a thermometric system comprising a temperature sensitive bulb 22 located in the conduit 1 beyond the nozzle 3, connected to a Bourdon tube 23 by a capillary 24. As known, the system may be filled with a gas,

vapor, or liquid, so that the pressure therein will vary in consonance with changes in temperature of the vapor within the conduit 1. As the temperature within the conduit 1 increases, the free end of the Bourdon tube 23 will be positioned in a clockwise direction, and as the temperature of the vapor decreases the free end will be positioned in a counterclockwise direction.

The Bourdon tube 23 is connected to the movable valve member 25 of a pilot valve 26 shown as being of the type forming the subject matter of United States patent to Clarence Johnson dated September 15, 1936, No. 2,054,464. Pressure fluid, such as compressed air, is admitted to the pilot valve 26 through an inlet pipe 27A. A pressure proportional to the position of valve member 25 is established in an outlet pipe 27. That is, as shown in the drawings, as the stem 25 is positioned upwardly the pressure within the pipe 27 increases proportionately, and as the stem is moved downwardly the pressure within the pipe 27 decreases proportionately. Accordingly, for every temperature within the conduit 1 there is a predetermined definite pressure established within the pipe 27.

The pipe 27 serves to transmit pressures to a standardizing relay 28 shown as being of the type forming the subject matter of United States Patent No. 2,098,914 to Harvard H. Gorrie. The relay 28 comprises a pair of chambers 29 and 30 separated by a pressure sensitive diaphragm 31, and a second pair of chambers 32 and 33 separated by a pressure sensitive diaphragm 34. Pressure fluid from any suitable source (not shown) is admitted to the chamber 33 through an inlet or supply valve 35 and exhausted therefrom through an exhaust or waste valve 36. Normally, valves 35 and 36 are closed. Tilting of a spring loaded fulcrumed beam 37 in one direction opens the valve 35, and tilting in the opposite direction opens the valve 36. The beam 37 is actuated by a member 38 operatively connecting diaphragms 31 and 34. Downward movement of the member 38 from the position shown serves to open the valve 35, thereby admitting pressure fluid to the chamber 33. Conversely, upward movement of the member 38 serves to open the valve 36, exhausting pressure fluid from the chamber 33.

The effective force acting on the diaphragm 34 is proportional to the difference in pressures within chambers 32 and 33. Likewise the effective force acting upon the diaphragm 31 is proportional to the difference in pressures within chambers 29 and 30. As shown, the chamber 30 is opened to the atmosphere through a port 39, so that the pressure therein remains substantially constant.

The relay 28 is adjusted by means of a spring 40 so that with equal pressures existing within chambers 32 and 33, and the pressure established by the pilot 26 at a value corresponding to the desired temperature of the desuperheated vapor, the valves 35 and 36 are closed. Upon an increase in temperature above the desired value the pressure within chamber 29 will increase proportionately and inlet valve 35 will open until the pressure within chamber 33 has increased a proportionate amount, or until the force acting upwardly on the diaphragm 34 again balances that acting downwardly on the diaphragm 31, when the condition of equilibrium will be restored.

Chambers 32 and 33 are shown in communication through an adjustable bleed valve 41. When the pressure within chamber 33 is increased to restore equilibrium, pressure fluid will slowly seep

through the valve 41, increasing the pressure within chamber 32. As the pressure within chamber 32 increases, the upwardly acting force on diaphragm 34 will decrease, causing the valve 35 to again open and increase the pressure within chamber 33 still further. Such regenerative action will continue as long as the temperature remains above the desired value, the fluid pressure within the chamber 33 gradually increasing at a rate dependent upon the extent of departure of the temperature from the desired value. As the temperature returns toward the desired value, the pressure within chamber 33 is decreased proportionately, and when the temperature is again at the desired value the pressure within chamber 33 will be equal to that within chamber 32, although at a different magnitude than existed previous to the original departure of the temperature of the desuperheated vapor from the desired value.

Upon a decrease in temperature below the desired value the reverse action occurs. The fluid pressure within chamber 33 is first reduced an amount proportional to the decrease in temperature and thereafter, due to the differential thus established between chambers 32 and 33, continuously reduced at a rate proportional to the decrease in temperature until the desired value of temperature is again restored.

Pressures established within the chamber 33 are transmitted to a diaphragm servo-motor 42 actuating the valve 6 through a pipe 43. As the temperature of the desuperheated vapor increases above the desired value the pressure effective within the servo-motor 42 increases and positions the valve 6 in an opening direction, thereby increasing the rate of water discharge from the nozzle 3 to restore the temperature of the desuperheated vapor in the conduit 1 to the desired value. Conversely, upon a decrease in temperature of the desuperheated vapor within the conduit 1 the fluid pressure within the servo-motor 42 is decreased, thereby positioning the valve 6 in a closing direction, decreasing the rate at which water is discharged from the nozzle 3 and restoring the temperature of the desuperheated vapor to the desired value.

Through the action of the standardizing relay 28 upon a change in the temperature of the desuperheated vapor the valve 6 is first positioned in a direction tending to prevent a further change in the temperature of the desuperheated vapor in the same direction as the original change. Thereafter the valve 6 is slowly moved in a direction tending to restore the temperature of the desuperheated vapor to the desired 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 the 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 having an orifice through which desuperheating fluid is discharged into the vapor to be desuperheated, and a nozzle for injecting vapor at a relatively high velocity into the fluid to be desuperheated located adjacent said discharge orifice.

2. A desuperheater comprising, a chamber having an orifice through which desuperheating fluid is discharged into the vapor to be desuperheated, and a plurality of nozzles for injecting vapor at a relatively high velocity into the fluid

to be desuperheated adjacent said discharge orifice.

3. A desuperheater comprising, a chamber having an orifice through which desuperheating liquid is discharged into the vapor to be desuperheated, and a plurality of nozzles for injecting vapor at a relatively high velocity into the zone beyond said orifice wherein said desuperheating liquid is being vaporized by the fluid to be desuperheated.

4. A desuperheater comprising, a chamber having an orifice through which the desuperheating fluid is discharged into the vapor to be desuperheated, and a plurality of nozzles arranged circumferentially about said orifice to discharge vapor at a relatively high velocity into the mixture of desuperheating fluid and vapor to be desuperheated.

5. A desuperheater comprising a chamber having an orifice through which desuperheating fluid is discharged into the vapor to be desuperheated, means for discharging said fluid from said orifice in the form of a diverging cone, and a plurality of nozzles arranged about said orifice for discharging vapor at a relatively high velocity in the form of a second cone enveloping said first cone.

6. A desuperheater comprising a chamber having an orifice through which desuperheating fluid is discharged into the vapor to be desuperheated, means for discharging said fluid in a direction having a component tangential to the wall of said orifice, a plurality of nozzles arranged about said orifice, and means for discharging vapor from said nozzles in a direction having a component tangential to said orifice.

7. A desuperheater comprising a cylindrical chamber having an axially located port through which the desuperheating fluid is discharged into the vapor to be desuperheated, a connection to said chamber extending tangentially of the curved wall of said chamber for admitting desuperheating fluid to the chamber, and a nozzle the center line of which is angularly inclined

with respect to the plane of said orifice and the projection of which to the plane of said connection is substantially parallel to said connection for discharging vapor into the vapor to be desuperheated.

8. A desuperheater for desuperheating flowing vapor, comprising in combination, a conduit through which the vapor to be desuperheated flows, a chamber having an orifice axially located in said conduit through which desuperheating fluid is discharged to the vapor to be desuperheated, means for producing a rotary motion of said fluid in one direction, a plurality of nozzles arranged circumferentially around said orifice for discharging streams of vapor into said conduit substantially parallel to the stream of desuperheating fluid discharged from said orifice, and means for producing a rotary motion of the vapor to be desuperheated passing said desuperheater in opposite direction to the rotary motion of said desuperheating fluid.

9. A desuperheater for desuperheating a flowing vapor comprising, a conduit through which the vapor to be desuperheated flows, a plurality of vanes in said conduit for producing a rotary motion of said flowing vapor, a second conduit within the first conduit axially aligned therewith, a nozzle member closing one end of said conduit provided with a plurality of angularly disposed passageways for discharging a second vapor into said first conduit in a conical form, a third conduit axially aligned with and within said second conduit closed at one end by said nozzle member; said nozzle member provided with a plurality of tangential convergent canals terminating in a common chamber having an axially positioned discharge orifice and forming a cone diverging axially from said orifice from the face of which emerges the passageways of said second conduit from which the vapor discharged impinges angularly on the oppositely whirling desuperheating liquid spray from said orifice.

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