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DESUPERHEATING VALVE

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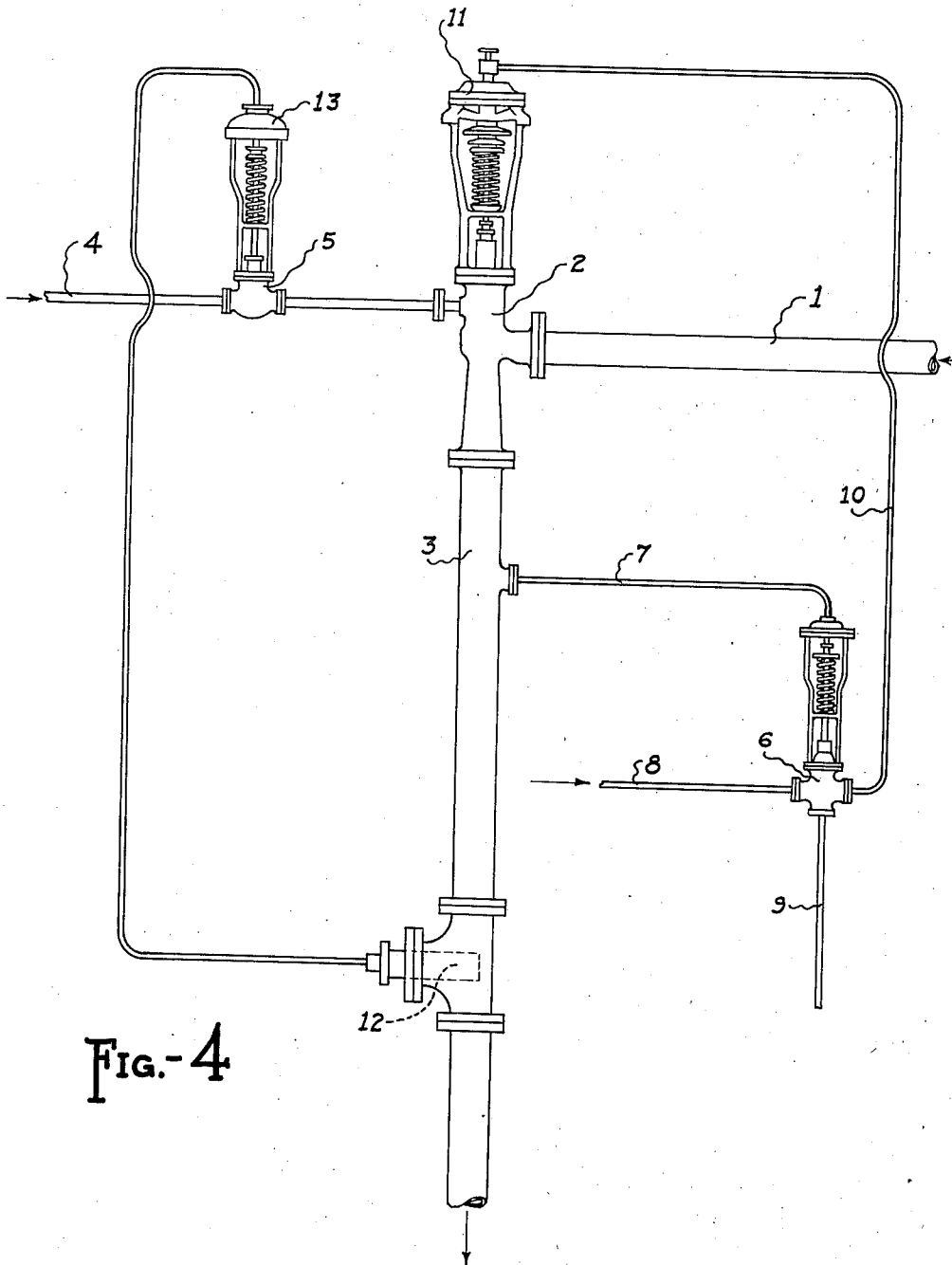


FIG.-4

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DESUPERHEATING VALVE

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12 Claims. (Cl. 122—479)

This invention relates to an apparatus for and a method of desuperheating steam. More particularly, this invention relates to a valve construction having both desuperheating and pressure reducing functions and to a method and means for introducing desuperheating water into superheated steam when the steam is caused to be in a highly receptive state or condition.

The problem of desuperheating becomes particularly difficult of solution when the requirements for desuperheated steam are relatively small and the flow of steam to which water is sought to be mixed and added is of "low" velocity moving in a relatively non-turbulent manner. Similarly, the problem of desuperheating is difficult of solution wherever a relatively great reduction in temperature is sought in a relatively small and slowly moving volume of steam. In the instant invention I have recognized that while the steam is not readily receptive of water in the relatively quiescent states above mentioned, the receptivity is greatly increased as the condition of the flow of steam becomes increasingly turbulent. I have also recognized that even when the demand for desuperheated steam is small that a highly turbulent condition of flow may be brought about and utilized within the valve that is restricting the flow and otherwise bringing about the relatively lazy or quiescent flow of steam beyond the valve.

Conditions of highly turbulent flow in the fluid streams are induced by abrupt changes in direction of the flow and also by the convergence of streams from opposite directions. Generally speaking, fluid streams moving at high velocity are more turbulent than the streams moving at low velocity, but one of the phenomena of which I have taken advantage is that, although the overall linear velocity of a stream may be relatively small, the internal velocities of different parts of a turbulent zone may be caused to be relatively high. In such a zone or condition of turbulence the steam is highly receptive of water, that is, the minute cross streams and the highly developed eddies and internal currents moving within the zone of turbulence are very effective in breaking up the water particles, shredding them into finely atomized form, and rendering the water particles highly receptive of the superheat of the steam whereby to cause the rapid vaporization of the water.

Thus in carrying out the objects of my invention I have not only turned to the valve which reduces the steam pressure as being a most opportune point for introducing the desuperheating

water, but also I have provided a valve and method in which I have preserved an efficient valving action so far as the steam is concerned and I have also provided a zone of high turbulence with means for introducing the desuperheating water into the zone of maximum or substantially maximum turbulence within the valve. I am aware that others in the prior art, witness the Peebles Patent No. 1,832,652 and the Howell Patent No. 2,138,064, have introduced water in or about reducing or throttling valves in the superheated steam line for the purpose of desuperheating, but nowhere has the prior art taught the creation of a highly turbulent steam flow within such valves or elsewhere with the introduction of the desuperheating fluid into the zone of turbulence, nor has the prior art taught the creation of a turbulent mixing zone within a reducing valve or elsewhere with any means for introducing the desuperheating fluid into such a zone.

One of the forces militating against effective desuperheating is the tendency of the desuperheating water to get into contact with the walls of the conduit or container, beside which the steam flows with relative quiescence, and to persist as a water stream on such walls without being "absorbed" by the steam. The water so wetting the walls of the steam conduit tends to run along the conduit in streams for relatively great distances, and if absorbed at all may not be taken up until it has passed beyond the point where the temperature or quality of desuperheated steam is measured for control of water input. To avoid this detrimental effect I provide for a very rapid absorption of the water on the one hand and on the other hand provide forces which tend to keep the water off the walls except where the steam flow is turbulent enough to "scrub" the water from the walls and get it or its vapor back into the stream. Moreover, in the prior art practices another problem has persisted, namely, the abrasive or sand blasting effect of raw water particles where they are given high velocity and then permitted to encounter the edges of valve seats or port openings or other parts, the shape and structural characteristics of which are necessary to efficient long-lived operation of the installation. In the practice of my invention this difficulty is avoided by introducing the water directly into the turbulent zone where the mixing and vaporizing action immediately takes place.

An object of my invention is to bring about the rapid and thorough mixing of the desuperheating fluid with the superheated steam with the consequent change in state of the former and transfer

of heat from the latter to the former in a simple, economical, rugged and efficient way. Another object is to provide a valve in which this desuperheating function is performed while simultaneously functioning as a reducing valve. By passing superheated steam through a plurality of ports in the walls of a hollow cylindrical valve closure member, out of one end of which the steam leaves, the steam is caused to enter the several ports in converging directions in one plane and then change its direction abruptly at substantially right angles to attain its transverse direction of outflow. Thus there is created not only the high turbulence by virtue of the abrupt change of direction, but also is the turbulence enhanced by the convergence of the flow through the several ports into the center of the valve closure member or disk. A particular object is to introduce the desuperheating fluid or water into the steam in this zone of maximum turbulence whereby to achieve the rapid breaking up of the water and its change of state in this highly turbulent zone.

Another object is to prevent the water from wetting the surfaces of the walls within which the steam flows or is contained, and this I accomplish both by the rapid absorption of the water and by directing the forces influencing its movement, disruption and volatilization to tend to maintain the water in the "core of the stream" for a sufficient period of time to permit its absorption and transformation.

Other objects will appear from the following description of certain preferred and modified forms of my invention hereinafter more fully set forth. The essential characteristics are summarized in the claims.

In the drawings Figure 1 is a partial sectional elevation of a complete desuperheating and reducing valve; Figure 2 is a partial vertical section of a modified form of the valve disk or closure member in a similar valve; Figure 3 is a further modification of a form of valve disk and a similar valve body, the valve being arranged, however, to open by an opposite movement of the disk or closure member from that shown in Figures 1 and 2; Figure 4 is an illustrative and partially diagrammatic layout showing a control system in which my desuperheating and reducing valve may be advantageously used.

Referring first to Figure 4 by way of illustration of an appropriate "hook-up" of a complete system, superheated steam may enter through the conduit 1 into the reducing and desuperheating valve 2 and leave as desuperheated steam through the conduit 3. Water from a source not shown may enter through the conduit 4, passing through a water control valve 5 into the body of the valve 2 through appropriate compartments and passages hereinafter to be described where it is mixed with the superheated steam to effect the desuperheating thereof.

The control of the flow of steam through the conduits 1 and 3 may appropriately be made responsive to steam pressure in the outlet pipe 3 as I have herein illustrated, or may, as is well known in the art, be controlled by various means for various specific purposes to which this invention does not particularly relate. To illustrate one form of control intended to maintain a substantially constant and/or reduced pressure in the pipe 3 a pilot valve 6 may be provided which may be of a type illustrated in my Patent No. 1,923,788, issued August 22, 1933, or in my copending application Serial No. 153,580, filed July 14, 1937, which pilot valve has imposed upon

its pressure responsive diaphragm the pressure of the pipe 3 through the conduit 7. Fluid pressure from any convenient source, not shown, is introduced to the valve 6 through the conduit 8. Communication from the valve 6 to atmosphere or a zone of reduced pressure is afforded through the conduit 9, and an intermediate working pressure rising and falling under the control of the valve 6 is delivered through the conduit 10 to the diaphragm or other pressure responsive element in the pressure chamber 11 on the valve 2, whereby to move the valve closure member therein to throttle the flow thereof more or less to maintain the desired pressure in the conduit 3. Where the valve disk or closure member of the valve 2 is ported as shown in Figures 1 and 2, downward motion thereof opens the ports of the reducing valve, and where the disk of the type shown in Figure 3 is employed, upward movement causes an opening of the ports of the valve. The connections through the pilot valve 6 may be appropriately arranged to effect either the upward or downward motion of the closure member of the valve 2, as is well understood in the art, and as may be desired for any particular installation.

The water control in the form herein shown for the purpose of illustration may comprise simply a bulb 12 containing expansible fluid responsive to the temperature of the desuperheated steam and generating pressure in the pressure chamber 13 of the valve 5 whereby to cause an increased flow of water into the valve 2 when the temperature in the pipe 3 tends to increase, and correspondingly restricting the input of water when the temperature of desuperheated steam in the pipe 3 tends to decrease below the desired limits or amounts. Those skilled in the art will understand that many variations of this elementary and illustrative hook-up have been practiced, and are well-known, and that this disclosure is for the mere purpose of illustrating the general arrangement of a system in which my valve and method may be advantageously used.

Turning now to Figure 1, the valve 2 may be seen to comprise a main body 20 having an inlet 21 and a tapered outlet 22, the angle of taper of the outlet 22 being preferably as shown and such as to discourage the deposition on the walls thereof of any free liquid carried in the stream. The valve disk 23 comprises a hollow generally cylindrical body vertically slidable within spaced upper and lower cylindrical seats 24 and 25, and has a plurality of circumferentially spaced ports 26 preferably of about the shape shown, whereby to give relatively small increments of change of opening in the initial opening period as compared with greater changes as the valve approaches its wide open position. Preferably the valve disk is ported as shown at a plurality of oppositely disposed circumferentially spaced points, and the steam from the inlet 21 surrounding the valve disk as in the chamber 21', tends to pass through the ports 26, or such portions thereof as are accessible to the steam, from a plurality of converging directions, in the horizontal plane as illustrated in Figure 1, all tending to converge into a central vortex or turbulent zone in the cylindrical disk where these converging streams meet and must abruptly change their ultimate direction at right angles to flow downwardly in a vertical direction. I thus provide a zone of great turbulence within the valve disk where the change of direction of a fluid stream is affected abruptly, and also great turbulence is induced by the convergence of the streams meeting each

other from the oppositely disposed ports. Even when the flow through the outlet 22 is small the velocity through the ports is high and this velocity along with the other forces mentioned above maintains a highly turbulent condition of steam in the disk 23 which is highly receptive of water even though the receptivity of steam is small in other parts of the system.

The closure member or disk 23 of the valve is preferably integrally formed with the valve stem 30, which as shown passes upwardly through a sealed and packed partition 31, which carries appropriate packing 32. The stem or an extension thereof has mechanical contact with a diaphragm 33 in the chamber 11 upon which appropriate operating pressures may be impressed to force the stem downwardly against the action of appropriate springs 34 adjustable by a nut or hand wheel 35, all as is well known in the art, and as mentioned above in the discussion of Figure 4.

Novel to this valve construction, however, is the chamber 40 adjacent the valve stem 30 and below the partition 31 formed within the upper extension of the body 20 of the valve 2. The lower portion of this chamber is closed from communication with the steam space of the valve by the upper end wall of the valve disk as at 41, except as this upper end wall has drilled passages 42 permitting fluid communication from the chamber 40 through the end of the valve disk into the interior portion thereof. Preferably the passages 42 are inclined as shown to direct the water inwardly and downwardly to the point of maximum turbulence within the disk 23. Leading into the chamber 40 is a conduit 43 through which water is conducted in measured amounts, controlled by the valve 5 shown in Figure 4, whereby the desuperheating fluid is caused to flow through the conduit 43 into the chamber 40, and thence through the passageways 42 into the interior of the valve disk and more particularly into the zone of maximum turbulence therein.

By introducing the water to the steam at this point of great turbulence, I am able to effect the rapid desuperheating of the steam, even when the flow through the valve 2 is very small. Since the water is introduced into the steam at the point where the incoming superheated steam is entering through a plurality of ports in converging directions, the water entering through the passages 42 tends to be forced into the center of the turbulent mass in the middle of the valve disk, and subjected to the forces tending to disrupt the liquid particles. Moreover, such liquid as might tend to get on any of the interior walls of the valve disk is also immediately subjected to the scrubbing action of the turbulent flow therein, and hence tended to be evaporated or scrubbed off the walls either in the vapor or more finely atomized form, so that none, or a bare minimum, of unvaporized or not highly atomized water tends to pass beyond the confines of the cylindrical valve disk as such.

In Figure 2 I have shown certain modifications, to wit, that the valve disk 23' being ported at 26' in the same way shown in Figure 1, and being associated with the water chamber 40 in the same way as shown and described in Figure 1, may have instead of the passages 42 shown specifically in Figure 1, passages 44 preferably leading to a central vertical passage 45 in which I prefer to insert a fitting 46, terminating in an exteriorly tapered or pointed orifice 47, which leads the incoming water directly to the center of the vortex and turbulence in the valve disk, 75

and which tends to reduce the possibility of water flowing from the end of the passage along the interior wall of the disk. In this modified form I also prefer that the lower inner edge of the skirt of the valve disk be inturned slightly as at 23a, whereby to tend to fleck inwardly, or fleck into the stream of downwardly flowing steam, any liquid that might have gained contact with the inner wall of the valve disk whereby to get that liquid back into the stream of steam to facilitate its absorption thereby. The slight in-turning of the skirt of the disk tends to give a little boost to the velocity and turbulence of the steam passing that point whereby to further shred or disrupt water particles not therefore broken up and absorbed in the portion of the disk more nearly adjacent the ports.

In Figure 3 in substantially the same valve body 20 with the same steam inlet and outlet and the same water chamber 40, I have shown a modified form of valve disk or closure member 50 with inverted ports 51, which ports are opened by an upward movement of the disk as distinguished from the downward opening movement of the disks shown and described in Figures 1 and 2. Otherwise the general operation of the valve is substantially the same, and water from the chamber 40 passes through passages 48 in the valve disk to the interior of the cylindrical portion thereof, but in this instance immediately above and adjacent the ports 51. The passages 48 are preferably drilled in interior ribs 52 preferably formed integrally and interiorly of the cylindrical portion of the valve closure member or disk 50. In this form of my invention the water moving downwardly through the passages 48 will always enter the steam stream near its point of highest velocity, since the upper portions of the ports will be first uncovered as the disk moves upwardly in its opening movement. The water so entering will be forced directly into the rapidly moving steam entering from the ports, and as in the other forms will be led with the converging streams to the central turbulent zone within the valve disk where it will be mixed and absorbed and subjected to all the turbulent action of the converging streams and the abrupt changes of direction thereof.

In this as in the other forms of my invention the water is introduced through the valve closure member or disk so that regardless of the movement of that member the relation of the ultimate water inlet to the turbulent body of steam is not substantially changed. In this form as in the other forms the water is introduced at or very close to the point of maximum steam turbulence and the water is quickly transformed from the liquid to the vaporous state with the consequent absorption of heat from the superheated steam.

In all of the forms of my invention the superheated steam is subjected to a method of desuperheating which is characterized by directing the steam to flow in radially converging paths at high velocities through the valve ports into the interior of the hollow cylindrical valve disk where the converging streams not only converge and collide but also change their direction of travel abruptly at substantially right angles from their horizontal plane of movement to the vertical direction as illustrated herein (reference to horizontal and vertical as such being made only for convenience in reference to the vertical position of the valve shown in the drawings here). In all instances according to my method and the practice of my invention the

water is introduced to the steam at or about its point of maximum turbulence. I am aware, of course, that there may be a variety of well founded theories as to what precise geometric point or points may have actual maximum turbulence within the cylindrical valve disk, and I do not confine myself to trying to predict what geometric point or points are those of actual maximum for all velocities and other conditions. It is my intention according to the practice of my method to bring the desuperheating water into the presence of the desuperheated steam in this turbulent zone which, as compared with the other and adjacent portions of the stream, is, as a whole, a zone of maximum turbulence. Moreover, according to my method and by the use of my valve structure, I cause the forces acting upon the water in the liquid state, to tend to force the water into the "core" of the stream rather than to tend to or permit the water to get to the walls which define the exterior of the stream other than in the zone of great turbulence where the scrubbing action is available to remove liquid therefrom. It will also be seen that the water is introduced to the steam interiorly of the valve ports so that no water is carried through any valve port nor permitted to impinge upon or be drawn across the restricting orifices comprising the coating ports and seats in the partially opened condition or the ports alone in the wide open condition. In this way the edges of the ports and seats are preserved against the abrasive or "wire drawing" effects which water or other liquid or solid particles exert upon the edges and walls of restricted orifices through which they are carried in rapidly moving vapor or gaseous streams.

While I have illustrated and described certain preferred and modified forms of my invention as a structure and combination of elements, and have described a preferred way of practicing my method, modifications and changes will appear to those skilled in the art without departing from the spirit or substance thereof, and I do not care to be limited to the preferred or specific modifications herein particularly disclosed or in any way other than by the claims appended hereto when construed to embrace the equivalents to which they are entitled in view of the prior art.

I claim:

1. A desuperheating valve having a steam inlet, a steam outlet, a water inlet, and a movable valve closure member having ports disposed to control the flow of steam from said steam inlet to said steam outlet, said closure member having passages therein distinct from said ports communicating with the steam outlet side thereof and with the said water inlet, said closure member constraining the flow of steam to change its direction abruptly and turbulently where water is introduced thereinto.

2. A desuperheating valve having a steam inlet, a steam outlet, a water inlet, and a movable valve closure member disposed to control the flow of steam from said steam inlet to said steam outlet, said movable closure member having one part exposed to said water inlet and another part exposed to said steam outlet and said closure member also having passages connecting said parts and communicating with the steam outlet and the said water inlet.

3. A valve having a steam inlet and a steam outlet and a hollow ported valve closure member movable to control the flow from said steam inlet

through the ports of the closure member to said steam outlet through said ports to induce a highly turbulent flow within said closure member, said valve also having a water inlet and means for introducing water through said closure member to the hollow interior thereof where the steam flow is turbulent.

4. In combination a conduit for superheated steam, a conduit for desuperheated steam disposed at an abrupt angle thereto, a hollow member having a closed end and an open end and a plurality of side orifices directing steam from said first conduit in radially converging paths within said member in a plane transverse to the movement of steam from the point of convergence of said paths through said open end to said conduit for desuperheated steam, and means for introducing water through the closed end of said member to said steam at a point of great turbulence substantially where said paths converge and change direction.

5. A desuperheating valve having spaced annular seats, a hollow cylindrical closure member slidably mounted in said seats and having oppositely disposed ports movable relative to at least one of said seats, a steam inlet chamber surrounding said member between said seats from which steam tends to enter the interior of said member through said ports, a water chamber adjacent said member beyond one of said seats and defined in part by a portion of said member, said member having at least one passage leading from said water chamber to the hollow interior thereof into the zone adjacent said ports.

6. The method of desuperheating flowing steam which consists in dividing the flow into a plurality of converging paths, moving the steam substantially in one plane in said converging paths to a central point, abruptly changing the direction of movement of said steam from said point transverse to said plane, and introducing water to said steam substantially at the point of maximum turbulence incident to said convergence and change of direction.

7. The method of desuperheating flowing steam which consists in dividing the flow thereof and causing the divided flows to converge from substantially opposite directions flowing substantially in a flat plane, increasing the velocity thereof as the converging flows tend to meet, abruptly changing the direction of movement of the converged flow to a direction transverse to said plane, and introducing water to said steam at substantially the point of maximum turbulence resulting from said movements.

8. A valve according to claim 5 in which said closure member has a restricted outlet opening through which the velocity of outflowing fluid is increased.

9. A desuperheating valve having spaced annular seats, a hollow cylindrical closure member slidably mounted in said seats and having a closed end and an open end and oppositely disposed ports movable relative to and adjacent at least one of said seats, a steam inlet chamber surrounding said member between said seats from which steam tends to enter the interior of said member in a radial direction through said ports, a water chamber adjacent the closed end of said member and defined in part thereby, said member having at least one passage leading through the closed end thereof from said water chamber to the hollow interior of said member radially inward of said ports.

10. The method of desuperheating flowing steam which consists in dividing the flow into a plurality of paths, causing said paths to converge from opposite directions, increasing the velocity of flow in said converging paths, abruptly changing the direction of flow at substantially right angles at substantially the point of convergence thereof, and introducing water to said steam after the velocity has been increased at substantially the point of maximum turbulence in said flow induced by said convergence and change of direction.

11. The method of desuperheating steam which consists in passing superheated steam into a reducing valve having a ported cylindrical closure member, leading said steam through the ports of said member in radially converging directions substantially in a plane normal to the axis of said member to a point of junction therein and out of said member in a direction transverse to said directions, and leading water to said steam through said member to the interior there-

of in a direction transverse to said radially converging directions substantially to the point of convergence thereof.

12. The method of desuperheating steam which consists in moving said steam substantially in a lineal direction toward a confined space, throttling the flow of said steam and increasing the velocity of its movement in said direction as it enters said space, abruptly changing its general direction of movement in said space through substantially a right angle to a second direction of movement of egress from said space whereby to produce a state of turbulent flow therein incident to said velocity and change of direction, introducing desuperheating water into said space at a point opposite the place of egress of said steam therefrom, moving said water into said space in a direction transverse to the first mentioned direction of movement of said steam to cause the water to meet the steam in its turbulent state in said space.

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