

July 19, 1960

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2,945,685

VARIABLE ORIFICE DESUPERHEATER

Filed Dec. 26, 1956

3 Sheets-Sheet 1

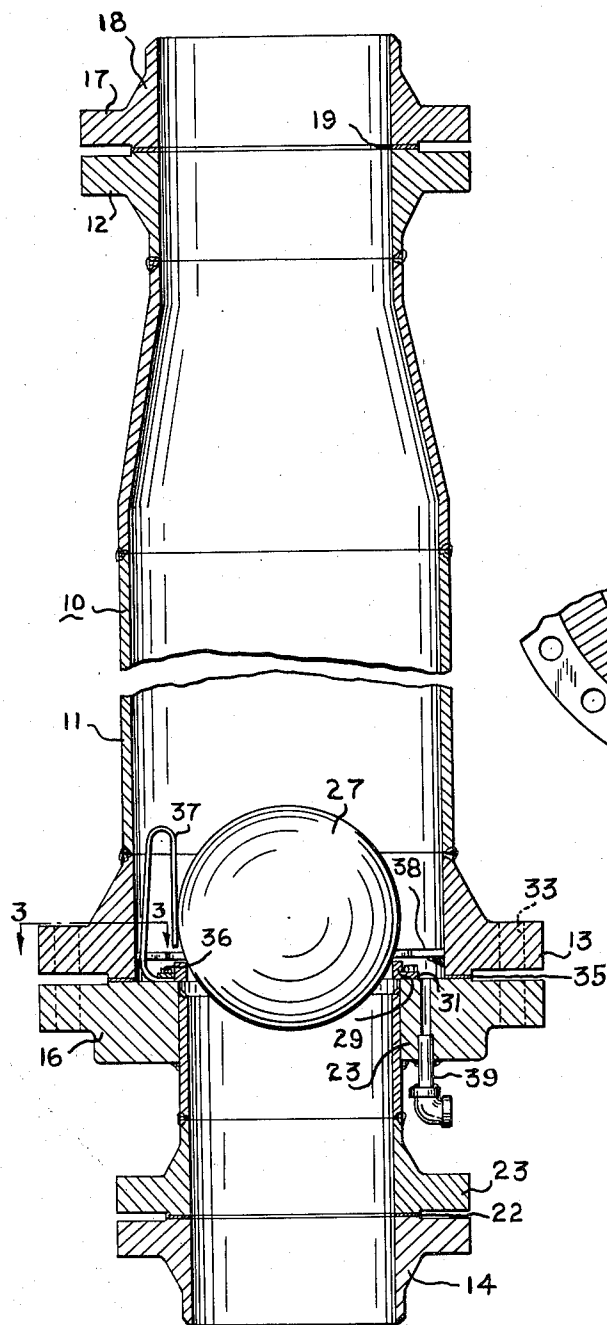


FIG. 1

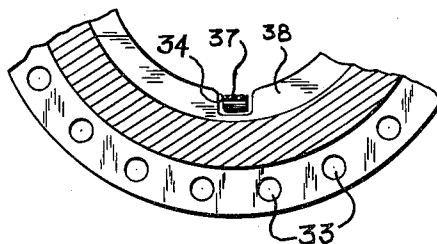


FIG. 3

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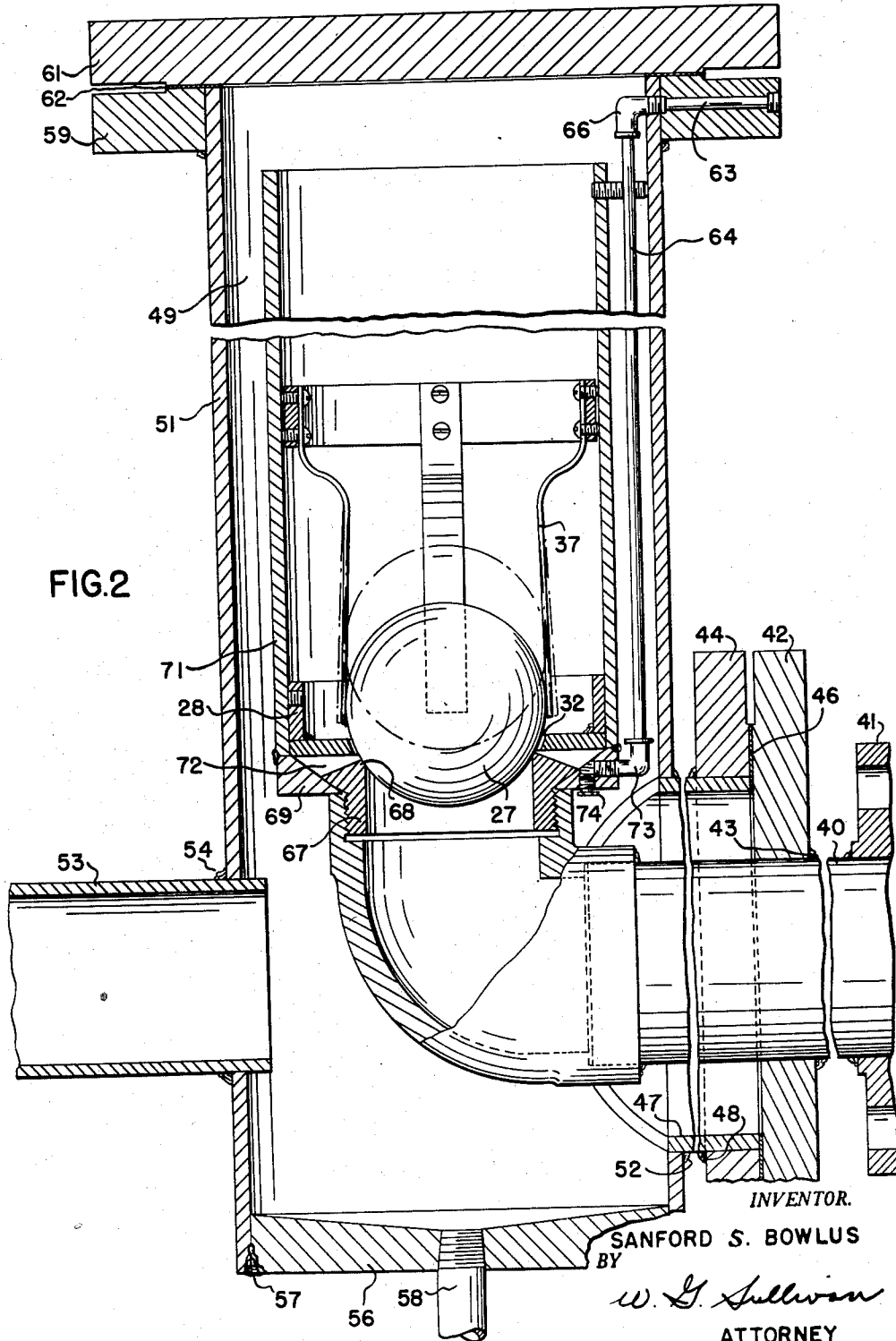
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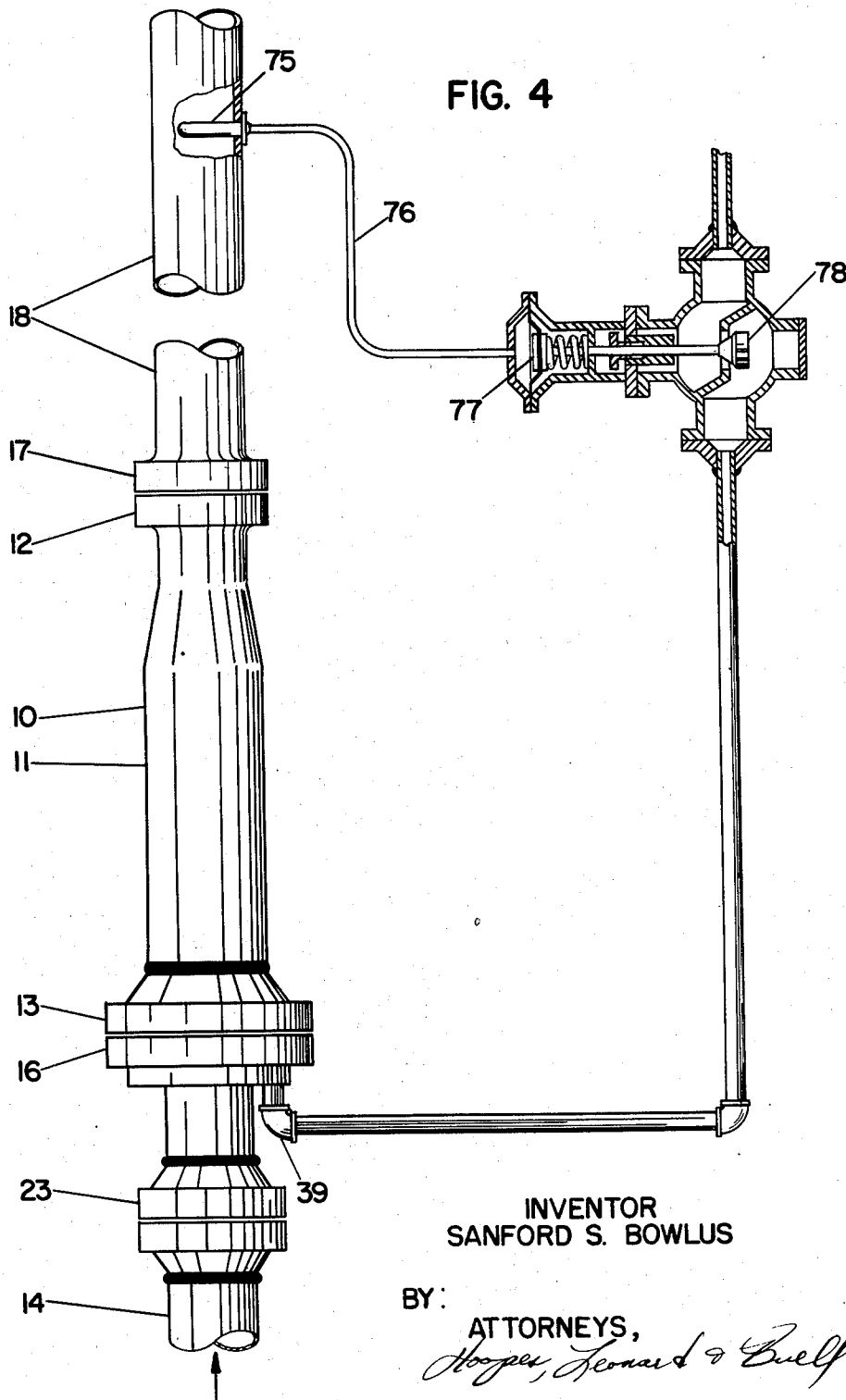
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3 Sheets-Sheet 3



1

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VARIABLE ORIFICE DESUPERHEATER

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1 Claim. (Cl. 261—62)

This invention relates to desuperheaters for reducing the temperature of gaseous fluids such as superheated steam by admixing cooling water with steam, and effecting rapid atomization by subjecting the admixture to a pressure drop by means of a restriction such as an orifice, and more particularly to a desuperheater of this type provided with a self-regulating orifice whereby the pressure drop will be substantially constant for all rates of steam flow.

I am aware that it is well known to desuperheat steam by the direct contact method wherein water is injected into the superheated steam. The resultant heating and vaporization of the water is achieved at the expense of the steam temperature with the end result of reducing the steam temperature.

If water were merely dumped into a line carrying superheated steam and if the line were long, the water lying on the bottom of the pipe would eventually vaporize completely and a uniform final temperature would be achieved (neglecting heat lost through the pipe). The difficulty with an arrangement of this type is the prohibitively long distance required to achieve the desired end result.

There are a number of well known methods of decreasing the distance required for completing the desuperheating operation. A first method is to inject water in as fine a spray as possible. This is done by utilizing spray nozzles of various designs, both mechanical nozzles and those employing steam as a means of breaking the water into small particles, thus speeding up the heat transfer process by virtue of the increased surfaces area of the water. Such methods are effective but have limitations due to the distance required for completion of the desuperheating operation as well as the variations of steam flow that can be handled. At low rates of steam flow the velocity of the steam being desuperheated is low and mixing is more difficult. An important limitation of the steam atomizing unit is the necessity of having a supply of atomizing steam available at some higher pressure.

A second effective method of achieving rapid atomization and completion of the process in a relatively short distance is to subject the steam (just after injecting the water) to a pressure drop by means of a venturi, orifice or other fixed restriction. The resulting turbulence, due to the drop in pressure, achieves the desired end result.

Although this second method is effective and does not require atomizing steam, it has a serious limitation due to possible variation in steam flow. Since the pressure drop across the fixed restriction varies as the square of the steam flow, a relatively high (and usually prohibitive) pressure drop is needed at highest flow rates to even get a limited range of operation. For example, at 10% steam flow the differential pressure is only one hundredth of the drop at 100% flow.

I have devised a relatively simple arrangement overcoming the aforesaid disadvantages and wherein a substantially constant pressure drop at all flow rates is pro-

2

duced resulting in excellent atomization over extreme variations in steam flow without introducing a prohibitively high pressure drop at higher rates of steam flow.

According to the invention, I provide a self-regulating orifice in the form of a ball adapted for limited axial movement in a steam flow line or mixing chamber and controlling the inlet to a mixing chamber. When steam is flowing through the line the ball is lifted from its seat and the resulting differential pressure is a function of the weight of the ball and the projected area of the ball on which the incoming steam acts. For every rate of steam flow there is a different position of the ball which results in equilibrium between the weight of the ball and the differential pressure lifting the ball.

As steam flows through the device, water is entrained at the point of greatest pressure drop. The amount of water is determined by the condition and quantity of steam flowing and is admitted by means of a conventional external regulating device, usually responsive to a temperature control means influenced by steam temperature. The steam and finely atomized water mixture leaves the device through a suitable outlet.

It is a primary object of the invention to provide a desuperheater for reducing the temperature of a gaseous fluid such as superheated steam to a desired value by admixing cooling water with the fluid at a pressure drop zone and adapted to control the pressure drop whereby it is substantially constant for all rates of steam flow.

Another object of the invention is to provide a desuperheater adapted to reduce the temperature of a gaseous fluid such as superheated steam to a desired value in a relatively short distance by highly atomizing cooling water supplied to the fluid and wherein the degree of atomization remains highly efficient despite wide variation in the rate of fluid flow.

Another object of the invention is to provide a desuperheater adapted to reduce the temperature of a gaseous fluid such as superheated steam to a desired value by admixing the fluid and cooling water at a pressure drop zone effected by a restricted orifice, and wherein the orifice is self-regulating with variation in rates of fluid flow whereby the pressure drop remains substantially constant resulting in highly efficient atomization of the fluid at all rates of fluid flow.

Another object of the invention is to provide a desuperheater of the above type which is highly efficient in operation and is relatively inexpensive to manufacture and install.

Other objects of the invention and the invention itself will become increasingly apparent from a consideration of the following description and drawings wherein:

Figure 1 is a longitudinal sectional view of a desuperheater embodying the invention installed in a vertically extending superheated steam or the like line;

Figure 2 is a view, mainly in longitudinal section, of a modification of the invention installed in a horizontally extending superheated steam or the like line;

Figure 3 is a fragmentary transverse section taken along the line 3—3 of Figure 1; and

Figure 4 is a view partly in elevation and partly in vertical cross section showing a valve controlling the cooling water supply openable and closable in response to steam temperature variation.

Referring now to the drawings, and particularly Figures 1 and 3, I have indicated my improved desuperheater generally at 10 and which comprises an elongate tube 11 having a top external flange 12 and a bottom external flange 13. A superheated steam or the like inflow line 14 is formed with an external flange 16 adapted to be sealingly connected to the lower flange 13 of tube 11 in a conventional manner by bolts projected

3

through holes 33 in flange 13 and aligned holes in flange 16 and secured by nuts. For simplicity of illustration the bolts and nuts have not been shown. In a similar manner an external flange 17 of an outflow line 18 is adapted to be connected to the top flange 12 of the tube 11. A sealing gasket 19 is disposed between flanges 12 and 17 and a similar gasket 35 is disposed between flanges 13 and 16. For ease in connection to a conventional inflow line I preferably provide an external flange 23 which is integrally connected to flange 16 by a relatively short tubular section. Flange 23 is adapted to be bolted to a cooperating external flange on line 14 with a sealing gasket 22 clamped therebetween. For practical reasons tube 11 and the tubular section including flanges 16 and 23 preferably comprise several parts welded together.

A ball 27 is adapted to seat on a ring element 29 having a flange portion 31 through which bolts are projected to threadedly engage flange 16 and firmly secure the ring element or seat to the inflow line. The flange portion 31 is notched at equally spaced points circumferentially to receive radially inwardly extending lower ends of spring members 37 which are secured to flange 16 by bolts or the like. The upper portion of each spring member is of inverted U form and the radially inner arm of the member is adapted to resiliently engage ball 27 and preferably slightly above a horizontal plane extending through the ball center when the ball is seated on ring element 29. Thus when the ball is seated the inner or ball contacting arm of spring member 37 will be inclined slightly from vertical with its upper portion nearest the axis of tube 11 whereby as the ball is lifted from its seat the spring members will be forced radially outwardly a slight amount. I preferably employ six equally spaced spring members 37 since I have found that this number have a desired stabilizing effect on the ball during fluid flow but it is understood that any suitable number may be used dependent upon the size of the ball and the like. Six spring members achieved a very satisfactory stabilizing effect when a ball eleven inches in diameter was used. Due to the turbulence created at the admixture zone during fluid flow there is a tendency to spin the ball 27 or move it eccentrically during fluid flow and I have found that the stabilizing means described effectively counteracts these tendencies.

Disposed slightly above the ring element 29 or the ball seat and extending radially inwardly to reduce the annular zone between ball 27 and the inner wall of tube 11 is a ring 38 which is secured to tube 11 in any suitable manner as by welding. Ring 38 is notched at spaced points as indicated at 34 (Figure 3) to provide clearance for spring members 37. The function of ring 38 which is termed a deflection ring is to limit fluid flow to a relatively narrow zone encircling ball 27 and insure that maximum turbulence and resultant highly efficient admixture occurs in this zone. I have found that without a deflection ring the zone adjacent the inner wall of tube 11 is relatively quiet during fluid flow and resultantly contributes relatively little to the admixing effect. However, after admixing it is desired that a minimum resistance to fluid flow be effected and this is accomplished by immediately enlarging the flow area above ring 38 to the inner walls of tube 11.

It will be noted that flange 16 is thickened as indicated at 23 and this portion of the flange has a step shouldered opening adapted to receive a conduit 39, preferably welded to the flange, which terminates downwardly in an elbow adapted to be connected to a source of cooling water. The upper end of conduit 39 leads to an annular chamber 36 formed by the upper face of flange 16, the inner wall of tube 11, the outer wall of ring element 29, and the bottom face of deflection ring 38. Chamber 36 has a circular outlet passage formed between the radially inner edge of deflection ring 38 and the lip of ring element 29 whereby cooling water is

4

directed to the turbulent or admixture zone. The cooling water will be delivered to the chamber 36 in an amount demanded by the condition and quantity of the steam or the like flowing to achieve a desired steam temperature at a pre-determined point or zone in the outflow line 18. The means for controlling the flow or amount of cooling water are well known and may comprise a bulb 75 inserted in line 18 at a desired point. Pressure in a fluid line 76 connected to the bulb will vary in accordance with steam temperature variation and resultantly operate a fluid pressure motor 77 controlling the cooling water valve 78 whereby cooling water will be delivered through the conduit 39 in amounts sufficient to maintain the steam temperature.

The operation of the desuperheater will now be described. In a manner previously described cooling water will be delivered to chamber 36 just above ring element 29 or the ball seat in amounts required to maintain the steam temperature substantially constant at a pre-determined point in the outflow line 18 and will flow annularly around the ball. In order for steam to flow through the desuperheater or device the steam must lift the ball from its seat. As the ball is lifted and fluid flow occurs a differential pressure is created between the downstream and upstream sides of the orifice and this differential pressure effective on the projected area of the ball tends to keep the ball lifted but is opposed by the weight of the ball so that for a given rate of fluid flow the ball comes to a state of rest or equilibrium which is a function of the differential pressure created and the weight of the ball. Thus for every different rate of steam flow there is a different position of the ball resulting in equilibrium between the weight of the ball and the effective differential pressure tending to lift the ball. Since the weight of the ball is constant and the differential pressure, with the ball lifted, can be considered effective on the projected area of the ball or on a constant area corresponding to the area of a horizontally disposed disc having the same diameter as the ball, it will be apparent that any time the ball is at rest during fluid flow the pressure differential and resultantly the pressure drop across the orifice is substantially constant.

As explained above the pressure drop can be maintained substantially constant despite wide or extreme variations in rates of fluid flow and since a desired turbulence and resultant highly effective atomization can be achieved with a given pressure drop maintained by the self-regulating orifice described, it is not necessary to encounter undesirably high pressure drops at high rates of flow in order to achieve desirable minimum pressure drops with low rates of flow as necessarily occurs with prior fixed restrictions or orifices with which I am familiar.

It will be noted that the chamber 36 which receives the cooling water is just above the ball seat or the zone of greatest pressure drop whereby the water is entrained in the steam or other high temperature gas at this zone resulting in a highly efficient admixture at the zone of greatest turbulence.

The foregoing description relates to installation of the device in a vertically extending fluid flow line and since the weight of the ball is utilized the adaption of the device to a horizontally extending line will now be explained in connection with Figure 2. I have indicated at 40, a generally L-shaped conduit which can be sealingly connected to a high temperature fluid inlet line in a conventional manner by means of a perforated external flange 41. Conduit 40 projects through a supporting plate or flange 42 and is welded thereto as indicated at 43. A second plate or flange 44 encircles a relatively short tube 47 and is welded thereto as indicated at 48. Flanges 42 and 44 are bolted together in a conventional manner with a sealing gasket 46 therebetween.

Tube 47 forms the horizontal extension of a vertically disposed annular chamber, generally indicated at 49, hav-

5

ing an outer wall formed by a vertically extending tube 51 perforated to receive tube 47 to which it is welded as indicated at 52. The opposite wall of tube 51 is perforated to receive a conduit 53, preferably joined thereto by welding as indicated at 54, and providing a fluid outlet line. Tube 51 is closed at its lower end by a plate 56 welded thereto as indicated at 57 and formed to provide a sump leading to a drain conduit 58. The upper end of tube 51 is provided with an external flange 59 suitably secured thereto as by welding which is adapted to be secured to a plate 61, by bolts or the like not shown, which closes the upper end of tube 51 by sealing gasket 62. Flange 59 has an opening 63 therethrough adapted to be connected at its outer end with a source of cooling water and communicating at its inner end with a vertically extending pipe 64 through an elbow 66.

Conduit 40 is preferably formed by a straight horizontal tube portion and an elbow welded thereto, the upstanding portion of the elbow being threaded to receive a ring member 67. Member 67 terminates upwardly in a bevelled seat 68 adapted to engage and support a ball 27 as described in connection with Figure 1. Member 67 has a radially outwardly extending generally V-shaped flange having a lower face adapted to exert gripping pressure on the inclined upper face of a ring shaped element 69 seated on the upper or elbow end of conduit 40. Element 69 is welded or otherwise secured to the bottom of a tube 71 radially inwardly spaced from tube 51 and forming the inner wall of vertically extending annular chamber 49. A cup element 28 abuts the inner wall of tube 71 and is fastened thereto in any suitable manner.

It will be noted that cup member 28 has its base perforated to provide an annular slot 32 between the ball 27 and said base and that the bottom face of the cup member base, the inclined upper face of ring member 67, and the inclined upper face of ring element 69 form an annular chamber, indicated at 72, which is generally triangular shaped in cross-section. This chamber is adapted to receive cooling water from pipe 64 through an elbow 73 threaded into ring element 69. Elbow 73 preferably communicates with chamber 72 through a threaded opening closed by a drain plug 74.

The ball 27 is stabilized or maintained substantially concentric with the openings in ring member 67 and cup member 28 by spring members 37 as explained in connection with Figure 1.

The operation of the desuperheater or device will no doubt be apparent from the explanation relative to Figure 1 inasmuch as the modification essentially comprises adapting the arrangement of Figure 1 to a horizontally extending fluid flow line but a brief description of the operation will be given. Incoming superheated steam or a similar gas to be reduced in temperature flows through conduit 40 when sufficient pressure is attained to lift ball 27 from its seat 68. As previously explained this will create a substantially constant fluid pressure differential

6

or pressure drop across the orifice defined by seat 68 and the ball 27 whereby water from chamber 72 will be entrained or admixed with the incoming steam or the like. The entrained water will be highly atomized at the zone of greatest pressure drop and the resulting mixture of steam and atomized cooling water will flow over the top of tube 71, downwardly through channel 49 and be discharged through outlet conduit 53.

It is understood that although I have primarily described the invention in connection with desuperheating or lowering the temperature of superheated steam that it is equally adaptable to reducing the temperature of various other high temperature gaseous fluids such as air.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described for obvious modification will occur to persons skilled in the art.

What I claim is as follows:

A desuperheater device adapted to be installed in a horizontally extending fluid line for high temperature gaseous fluid such as superheated steam whereby the temperature of said fluid may be reduced by admixing cooling water with the fluid and highly atomizing said cooling water due to a pressure drop in said line created by and maintained substantially constant by said device despite wide variation in rates of fluid flow, said device comprising an upright tube adapted to communicate with a fluid inflow line and a fluid outflow line whereby all fluid flowing between the inflow and outflow lines traverses said tube, said tube having and L shaped lower extension adapted to connect with a downstream portion of the line, the said tube being open at the top, a second tube closed at the top and encircling the said first tube in spaced relation to form a chamber therearound adapted to receive an admixture of fluid and cooling water flowing from the first tube, the second tube being formed with an outlet adapted to connect with an upstream portion of the fluid line, means disposed in said first tube providing a restricted and variable orifice during fluid flow, said means being self-regulating to provide a substantially constant pressure drop across said orifice despite wide variation in rates of fluid flow, and cooling water supply means adapted to deliver water to said first tube at the pressure drop zone whereby the cooling water will be entrained in the fluid and highly atomized due to turbulence created by fluid passing through said zone.

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