

May 15, 1962

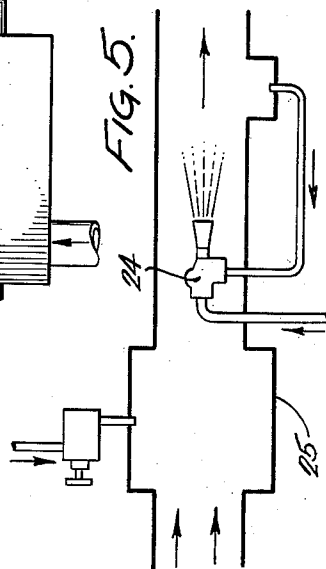
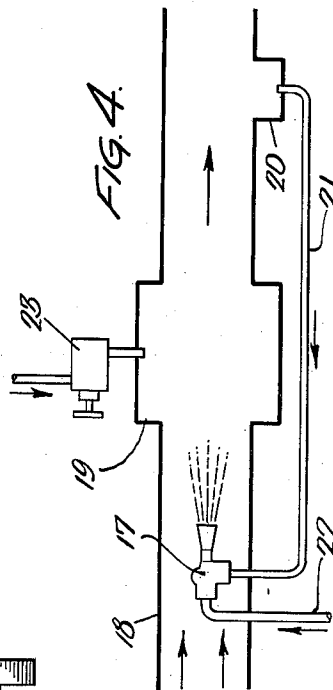
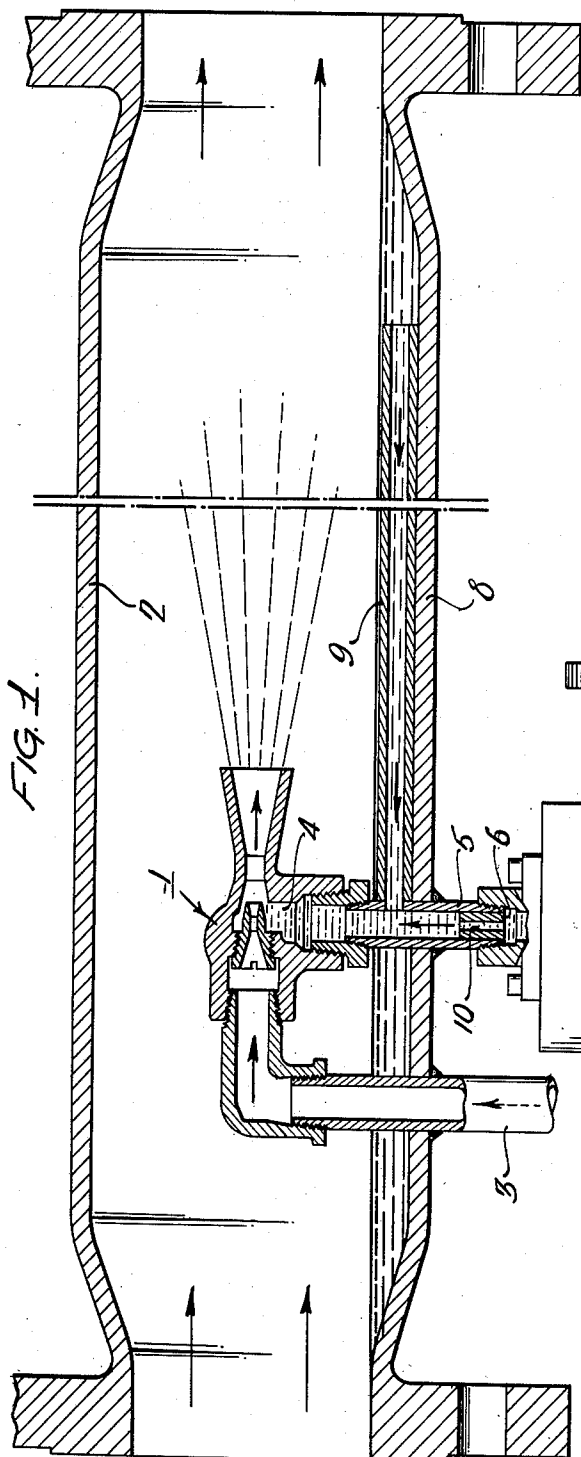
LE ROY S. HARRIS

3,034,771

DESUPERHEATER

Filed Nov. 6, 1958

4 Sheets-Sheet 1



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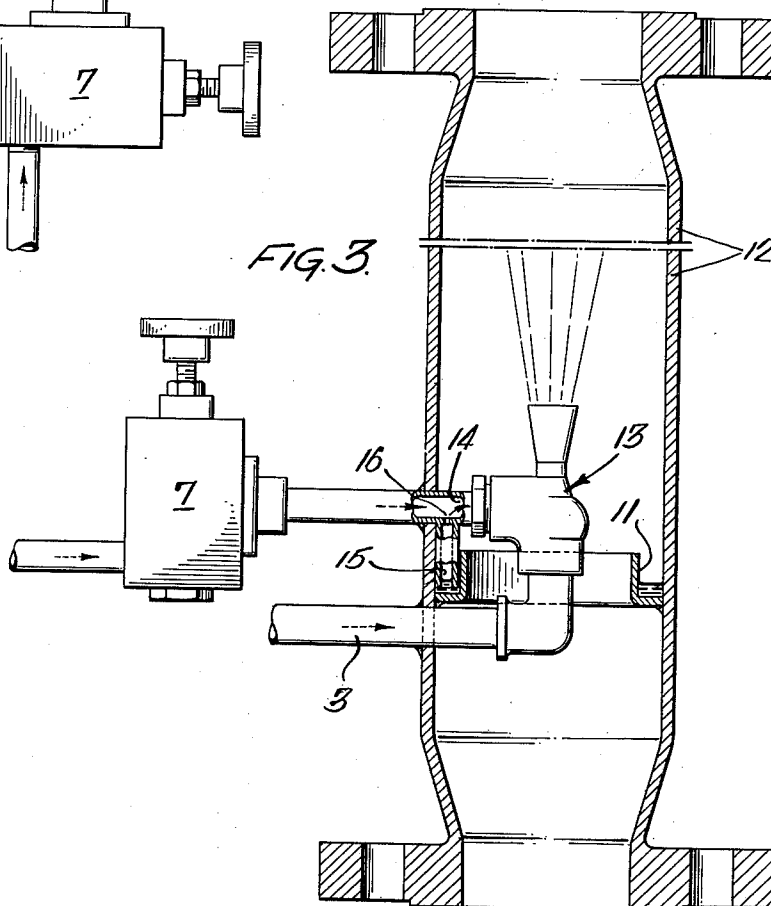
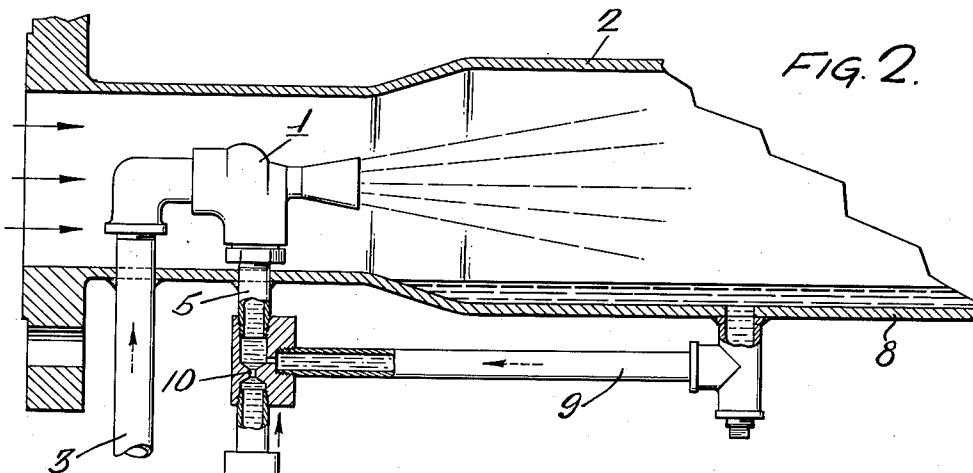
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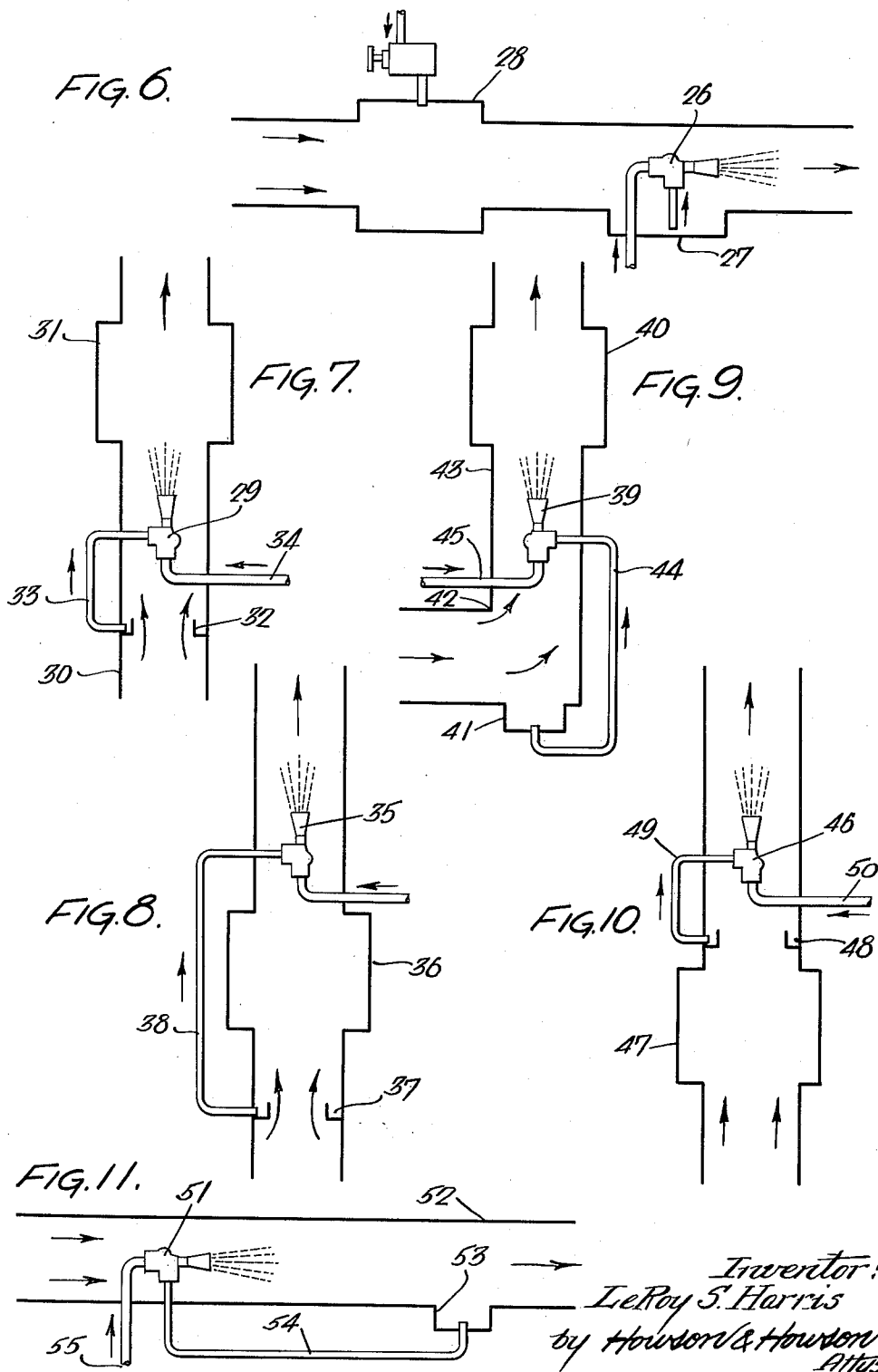
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FIG. 12.

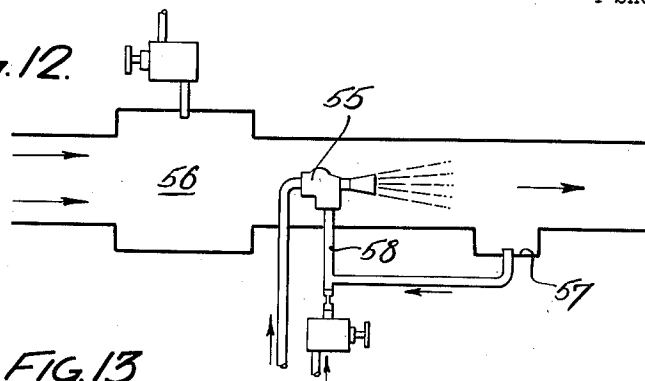


FIG. 13.

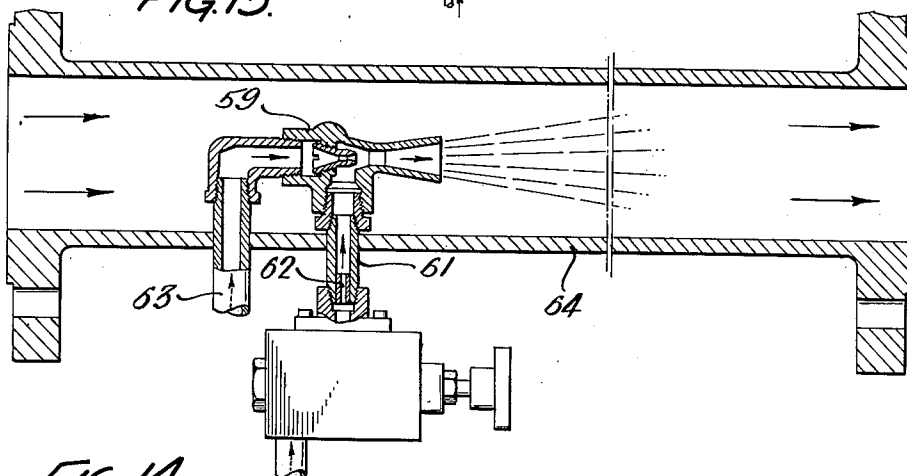


FIG. 14.

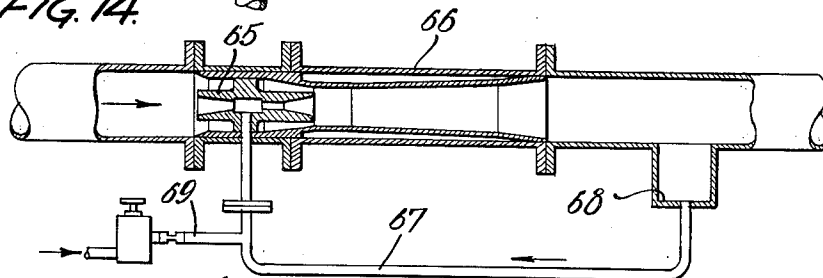
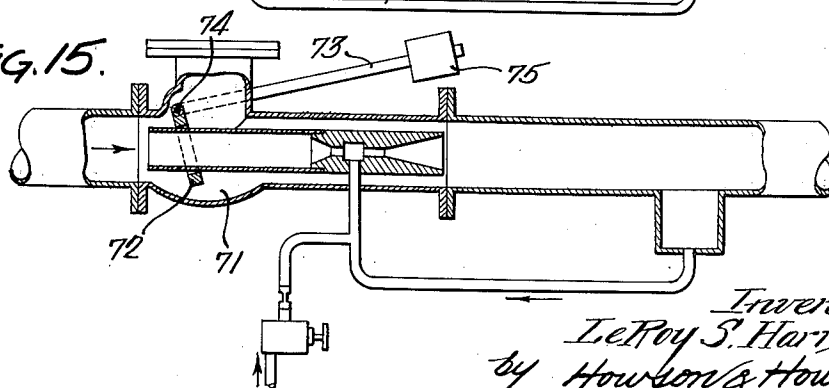


FIG. 15.



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3,034,771

DESUPERHEATER

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2 Claims. (Cl. 261—36)

This invention relates to improvements in steam desuperheaters, and a principal object of the invention is to provide a desuperheater capable of efficient operation over a relatively wide range of variation in flow of steam from the primary source between 100% of full capacity to practically 0%.

Another object of the invention is to provide a simple and highly practical means for extending the said range of efficient operation of existing desuperheaters.

Still another object is to provide a simple and effective means for utilizing the condensate in steam lines for desuperheating the steam in the latter.

More specifically stated, the invention contemplates the use in a steam line or conduit of means for continuously scavenging water present in the conduit and for immediately injecting the water in atomized form through an independent recycling system into direct evaporative contact with the steam to cool the latter. The water may consist of the condensate formed by pipeline heat losses, or it may consist of water otherwise collecting in the line as hereinafter described.

A further object of the invention is to provide a novel, relatively simple, and highly efficient form of desuperheater, as well as the use of the desuperheater as a medium for effecting the aforesaid recycling operation.

Apparatus embodying the invention is illustrated in the attached drawings, wherein:

FIG. 1 is a sectional elevational view of a horizontal desuperheater installation;

FIG. 2 is a fragmentary sectional view of a modified form of desuperheater installation;

FIG. 3 is a sectional view of a desuperheater assembly of vertical type;

FIGS. 4, 5 and 6 illustrate diagrammatically and respectively three other forms of horizontal installation within the scope of the invention;

FIGS. 7, 8, 9, and 10 illustrate diagrammatically and respectively four different types of vertical installations in accordance with the invention;

FIG. 11 is a diagrammatic view of still another embodiment within the scope of the invention;

FIG. 12 is a diagrammatic view corresponding generally to the view of FIG. 5, showing the ejector connected to an external source of water in accordance with the principle shown in FIG. 1.

FIG. 13 is a sectional elevational view corresponding generally to FIG. 1, but showing an ejector of the type illustrated in the latter figure, used per se as a desuperheating medium in the absence of the recycling means illustrated in FIG. 1.

FIG. 14 is a diagrammatic view showing a venturi type of desuperheater comprising recycling means in accordance with the present invention, and

FIG. 15 is a view of a corresponding type of the desuperheater including means for regulating the pressure drop across the venturi.

Theoretical and experimental investigations have revealed that the direct evaporative contact desuperheater process does not occur instantaneously. Under some conditions some particles of desuperheating water brought into the superheated steam will not be completely evaporated and will in part collect in the bottom of the steam conduit with very little desuperheating effect upon the main steam stream. The amount of the desuperheating

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water not participating in full degree in the process will depend on a number of factors including the velocity of the superheated steam, the size of the droplets of injected water, the density of the superheated steam, the amount of superheat, and the degree of superheating desired.

At the lower steam flows and pipeline velocities, wherein it has been found that the injected water particles are not finely atomized, the particles will not stay entrained in the steam stream for a sufficient time and distance to perform their desuperheating function and will tend to settle out of the stream onto the walls of the steam conduit. Consequently, at the lower flows, if the theoretical amount of water required to achieve the desired degree of desuperheating is injected, a portion of the water will settle out and thus keep the stream from attaining the desired degree of desuperheat within the required pipeline distance.

The recycling arrangement described below provides for scavenging and reinjection of the water settling out into the bottom of the conduit. In so doing, an amount of water in excess of the theoretical quantity required to desuperheat the steam is continuously injected into the stream and is absorbed by the steam to afford the desired degree of desuperheating with the water flow control valve supplying only the theoretical amount required during conditions of equilibrium.

I have discovered also that a steam ejector possesses functional characteristics well suited to the requirements indicated above of a desuperheater of the class to which the invention relates. Thus, the high velocity steam passing through a steam ejector is capable of:

(1) Finely atomizing water supplied through its suction chamber;

(2) Mixing the atomized water with the steam; and

(3) Imparting a high velocity to the water particles so that they will stay entrained in a steam stream for a much greater distance and for a longer period of time than particles acting under the force of gravity alone.

The principle of the invention will now be readily understood by reference to the drawings. In the typical installation shown in FIG. 1, a steam ejector 1 is mounted inside of the larger steam conduit or chamber 2 which is connected to the primary steam source (not shown), the direction of steam flow in the conduit being indicated by the arrow. The ejector is supplied with motivating steam through pipe 3 at a higher pressure, preferably from 50% to 100% higher, than the steam in conduit 2. Desuperheating water is supplied to the suction port 4 of the ejector by way of a pipe 5 having a restriction 6 and connected to the water source through a flow control valve 7. The motivating steam velocity in the ejector sucks water into its stream, atomizes and mixes the water with the steam, and injects the mixture into the steam flowing in the conduit.

In accordance with the invention, the conduit 2 is provided with a sink 8. The sink is connected directly to the suction port 4 of the ejector through a pipe 9 in the inside of the conduit and orifice 10. Due to the sucking action of the ejector, a low pressure is created within the latter. The orifice 10 controls the pressure of the desuperheating water between the ejector and the valve 7, this pressure being less than the pressure of the water between the valve and the source of supply, and substantially less than the pressure of the steam in the conduit. Since the pressure in the port 4 of the ejector is less than the pressure in the conduit, any water in the sink will be sucked back into the ejector and will mix with the water from the valve 7. The mixture is then atomized and injected into the conduit.

The valve 7 limits the amount of water drawn from the water source, and so limits the total quantity of

water passing to the ejector to the amount necessary to afford the desired degree of desuperheating. In this device the sink 8 and pipe 9 in their association with the ejector constitute in effect an independent recycling system entirely apart and separate from the primary steam system of which the conduit may form a part.

The device makes possible almost complete desuperheating of the main steam flow (within 10° F. of saturation) with flow variations extending over the full range from 100% maximum flow to 0% minimum, not including the amount of steam injected into the line by the ejector, which is of the order of 2% or less of the full capacity of the main steam flow. The device permits the injection of more water into the main steam flow than is theoretically required, the excess amount falling out of the main steam flow being continuously sucked back into the ejector where it is reatomized and reinjected to complete the aforescribed independent recycling operation. The device also provides for injection of the additional amount of water required to compensate the decrease in desuperheating efficiency, which occurs as the desuperheated temperature approaches saturation temperature of the steam (100% desuperheating) without need to supply and remove excess quantities of water to and from the system as the desuperheating efficiency decreases.

A modification of the arrangement described above is shown in FIG. 2. The modified arrangement comprises the same essential combination of elements and functions in the same manner as the arrangement of FIG. 1, and the corresponding parts are accordingly indicated by the same reference numerals. The sole structural difference lies in the fact that the pipe 9 which connects the sink 8 to the ejector 1, is located externally of the conduit 2.

The aforescribed embodiments of the invention are designed for horizontal installation of the conduit. In FIG. 3 I have illustrated an embodiment wherein the conduit is vertical. In this case the sink consists of an annular cupped receptacle 11 extending around the inside of the wall of the conduit 12, behind the ejector 13 in this instance. The suction port 14 of the ejector is connected to the sink by a pipe 15 and orifice 16. In this case free water in the duct flows down the wall of the conduit to the sink, and is recycled through the ejector. In all other respects the device corresponds to those previously described.

The principle of the invention may be used to improve the desuperheating efficiency of existing desuperheaters. In this phase of the invention the device can be used as an attachment or addition to many other types of desuperheaters. It can also be used independently as a means for utilizing condensate formed in a steam pipeline or conduit to desuperheat the steam, e.g., by atomizing and injecting the condensate formed by pipeline heat losses.

Typical installations in this phase of the invention are illustrated diagrammatically in FIGS. 4 to 11, inclusive:

In FIG. 4, the device consists of a steam ejector 17, installed in the conduit 18 before primary desuperheater with reference to direction of steam flow in the conduit, the primary desuperheater, which may be of various types, being indicated generally at 19. At the opposite side of the primary desuperheater, the conduit is provided with a sink 20, which is connected by a pipe 21 to the suction port of the ejector. Motive steam is received by the ejector through a pipe 22, the pressure of this steam being higher than that of the steam in the conduit. The sucking action of the motive steam velocity in the ejector causes the pressure at the suction port to be less than the pressure in the conduit, and as a result any water in the sink 20 will be sucked into the ejector, atomized, and injected into the main steam flow in the conduit. If the steam is superheated, all or a portion of the water injected will be absorbed by the steam, depending upon the

temperature and quantity of steam flowing through the conduit.

The majority of desuperheaters currently offered have a relatively limited range of operation, the lower limit of operation being the point where excess water has to be injected into the conduit in order to attain the desired degree of superheat. When a steam ejector is used in conjunction with the primary desuperheater, as described above, the range of operation of the system is increased. The ejector sucks up the excess water injected into the line by the primary desuperheater, as well as the water condensing on the wall of the conduit, and reatomizes the water and reinjects it into the main steam flow. The water flow to the primary desuperheater and to the ejector is controlled by a suitable water flow control valve 23 of the primary desuperheater.

The steam ejector may be located before or after the primary desuperheater, with reference to the direction of steam flow in the conduit, and in FIG. 5 I have illustrated a modification of the arrangement shown in FIG. 4, wherein the ejector 24 is positioned after the primary desuperheater 25. In the embodiment of FIG. 5 the mode of operation is identical with that of the embodiment of FIG. 4, described above, and the installation involves the same essential elements.

FIG. 6 shows a further modification, wherein the ejector 26 is positioned directly over the sink 27 after the primary desuperheater 28. Except for the location of the ejector, the apparatus is identical with that shown in FIG. 5, and functions in like manner.

The location of the sink with respect to the steam ejector and to the primary desuperheater will depend upon the type of installation. In a horizontal line such as illustrated in FIGS. 4, 5, and 6, the sink will preferably be located after the primary desuperheater, and the steam ejector can be located either before or after the primary desuperheater, as shown.

In FIGS. 7, 8, 9 and 10 I have illustrated desirable arrangements for vertical installations, i.e.; installations in which the conduit is upright. In FIG. 7 the ejector 29 is mounted in the conduit 30 below the primary desuperheater 31. In this case the sink takes the form of a cupped receptacle 32, which extends around the inner surface of the conduit below the primary desuperheater and below the ejector. The sink is connected to the suction port of the ejector by pipe 33; and motive steam is received by the ejector through pipe 34. In all other respects the embodiment of FIG. 7 corresponds to those described above.

In FIG. 8, the ejector 35 is mounted above the primary desuperheater 36, and is connected to the sink 37 by suction line 38. In all other respects, and functionally, the embodiment of FIG. 8 corresponds to that of FIG. 7.

In FIG. 9, the ejector 39 is positioned below the primary desuperheater 40 as in the embodiment of FIG. 7. In this case, however, the sink 41 is in the bottom of an elbow 42 in the conduit 43. The sink lies directly below and in line with the ejector, and with the primary desuperheater. The ejector 39 is connected to the sink 41 by a suction pipe 44, and motive steam is brought to the ejector through a pipe 45. Functionally, the embodiment of FIG. 9 corresponds to the embodiments previously described.

In FIG. 10, the ejector 46 is positioned above the primary desuperheater 47 as in FIG. 8, but contrary to the assembly disclosed in the latter figure, the sink 48 is located above the primary desuperheater. As in the other embodiments, the sink is connected by a suction pipe 49 to the suction port of the ejector, and motive steam is brought to the ejector through pipe 50.

It is obvious that in the absence of the primary desuperheater in any of the embodiments of FIGS. 4 to 10 inclusive, the ejector connected to the sink as illustrated may function in itself as a medium for utilizing condensate in the conduit as a medium for desuperheating

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the steam from the primary source with which the conduit is connected. This is illustrated in FIG. 11, wherein an ejector 51 is mounted in a steam conduit 52 having a sink 53 with which the ejector is connected, as described above, by suction pipe 54, motive steam being conducted to the ejector through pipe 55.

The modification of FIG. 12 corresponding generally to the embodiments of FIGS. 4 to 10, departs only in the one essential respect that the suction port of the ejector 55, which in this case is placed after the primary desuperheater 56 as in FIG. 5, is connected to a water supply source as well as to the sink 57 by way of the valve-controlled and orificed pipe 58, thereby affording greater latitude in the amount of water injected through the ejector.

The invention also contemplates, as indicated above, the use of an ejector of the form shown in FIG. 1 as a desuperheating device per se, and entirely independently of the recycling feature. I have discovered that an ejector of this form employing high velocity motive steam and means for limiting the amount and pressure of water drawn to the suction port of the ejector is functionally well adapted for desuperheating purpose. An ejector so used is illustrated in FIG. 13, wherein the water passing to the ejector 59 through pipe 61 is limited in pressure by orifice 62 and in quantity by valve 60 so that it conforms with the amount of desuperheating desired.

The invention is also capable of embodiment utilizing other types of desuperheaters, such, for example, as the venturi type, variable and fixed orifice types, and desuperheaters having high velocity nozzles. The use of any of these types will be understood by reference to FIGS. 14 and 15 which illustrate installations of the venturi type. In FIG. 14, the venturi 65 is mounted in the conduit 66 in conventional manner, and is connected as shown through pipe 67 with a sink 68. Steam from the primary source discharging through the venturi creates the suction which draws water from the sink through pipe 67 to the venturi, together, in the present instance, with water from a source connected with the pipe 69, as in embodiments described above. The water is atomized in the venturi and is injected with the steam into the conduit. In this case no secondary high pressure steam is required.

FIG. 15 shows a modified venturi application wherein means is provided for regulating the pressure drop across the desuperheater. In this case provision is made for regulated by-passing of steam from the source at the outside of the venturi through channel 71. This by-pass is controlled by a valve 72, adjustable from outside the conduit. The adjustment may be made automatic by biasing the valve against the steam pressure from the source through medium of an arm 73 on the pivot shaft 74 of the valve and a weight 75 which may be adjustable on and longitudinally of the arm. In other respects the device functions in the same manner as the embodiment of FIG. 14.

I claim:

1. A system for desuperheating steam by entraining a

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predetermined quantity of water in said steam to effect a desired degree of desuperheating of the steam comprising; a conduit through which said steam passes, steam supply means for supplying superheated steam from a source to said conduit at a predetermined rate, a steam-operated ejector positioned within said conduit at substantially the longitudinal axis of said conduit and facing in the direction of the path of travel of the steam through said conduit, said ejector positioned substantially coaxial with said conduit and including a suction port, water-supply means operable to supply water to said suction port, pipe means interconnecting the water supply means and the suction port of said steam-operated ejector, a flow control valve in the pipe means between the water supply means and said suction port, said flow control valve being adjustable selectively to supply to the conduit the theoretical quantity of water for effecting the desired degree of desuperheating of said steam, a sink in fluid communication with a portion of said conduit downstream of said steam-operated ejector for continuously collecting all the water supplied to said conduit which does not remain entrained in said steam, means defining an unobstructed enclosed passageway extending from said sink and communicating with said pipe means at a point between said flow control valve and said suction port to continuously withdraw water from said sink and continuously convey the same to said suction port, the theoretical quantity of water supplied by the flow control valve and the water from said sink, collectively constituting the predetermined quantity of water required to effect the desired degree of desuperheating, and means to supply secondary steam to said steam-operated ejector at a higher pressure than the pressure of the steam in said conduit and cause said secondary steam of higher pressure to pass through said steam-operated ejector and over said suction port at a high velocity to withdraw by suction and to atomize the water supplied to said suction port from said water supply means and sink, to thereby continuously inject said water into said steam being desuperheated in said conduit.

2. A system according to claim 1 wherein the conduit is substantially horizontally disposed.

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