

Nov. 30, 1965

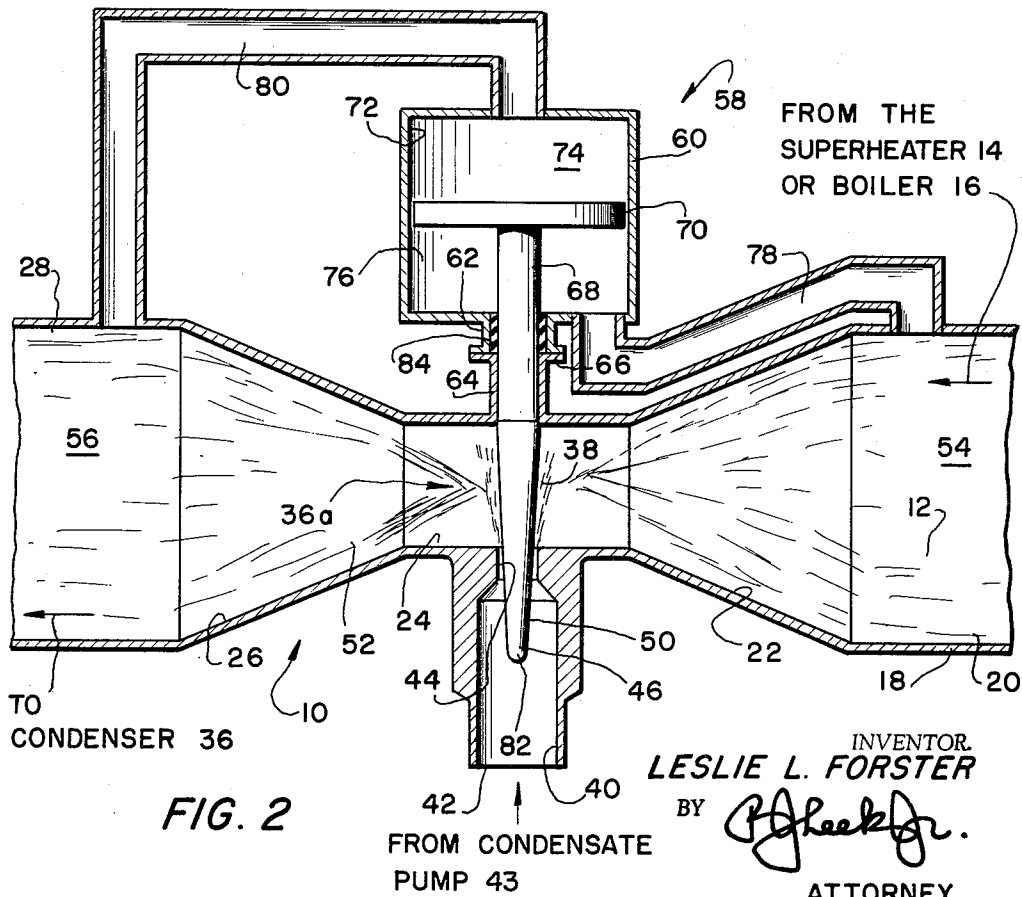
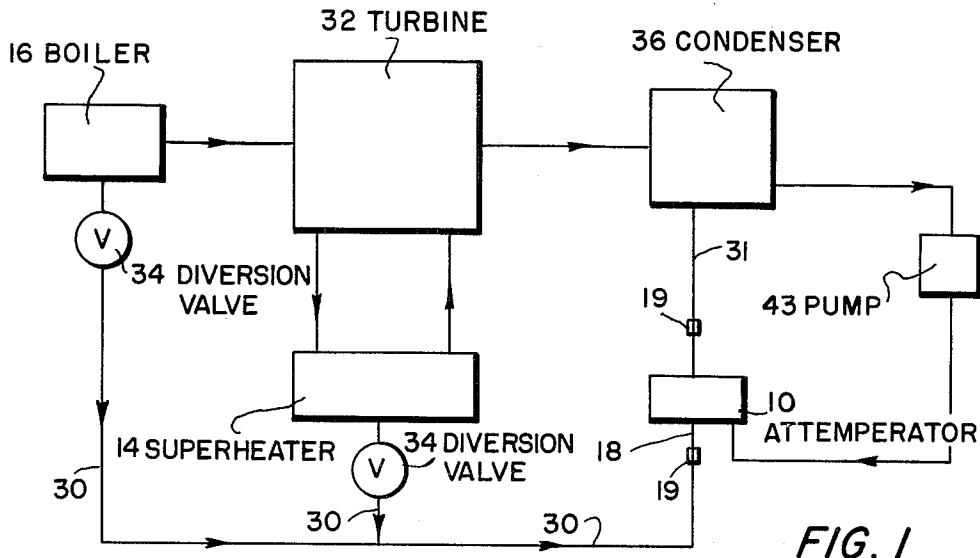
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3,220,710

SELF-REGULATING ATTEMPERATOR

Filed April 23, 1963

4 Sheets-Sheet 1



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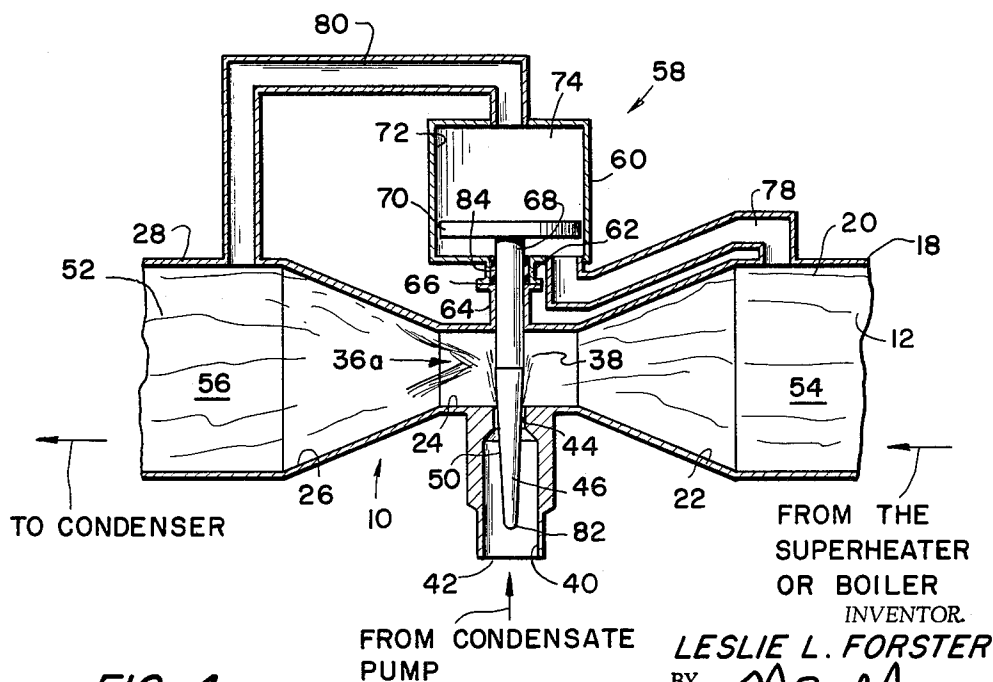
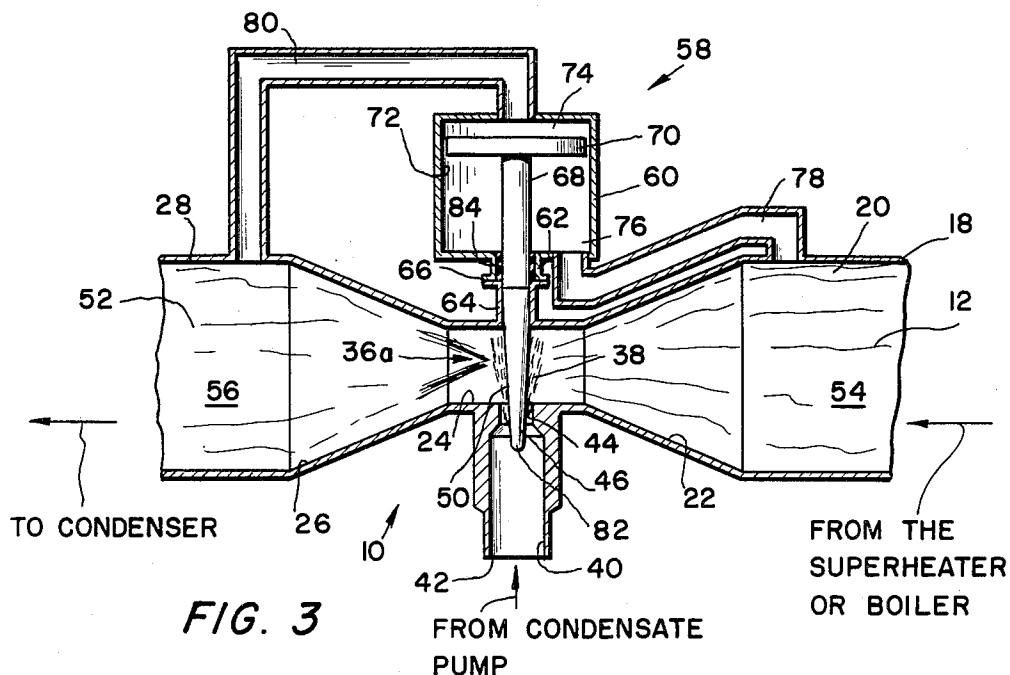
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SELF-REGULATING ATTEMPERATOR

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4 Sheets-Sheet 2



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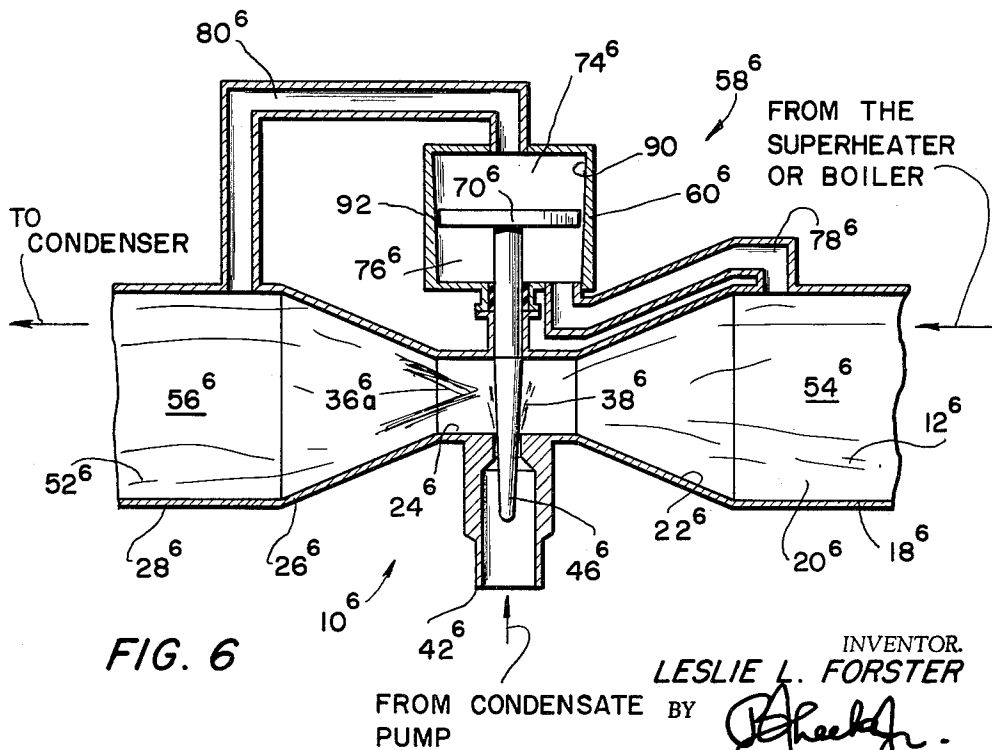
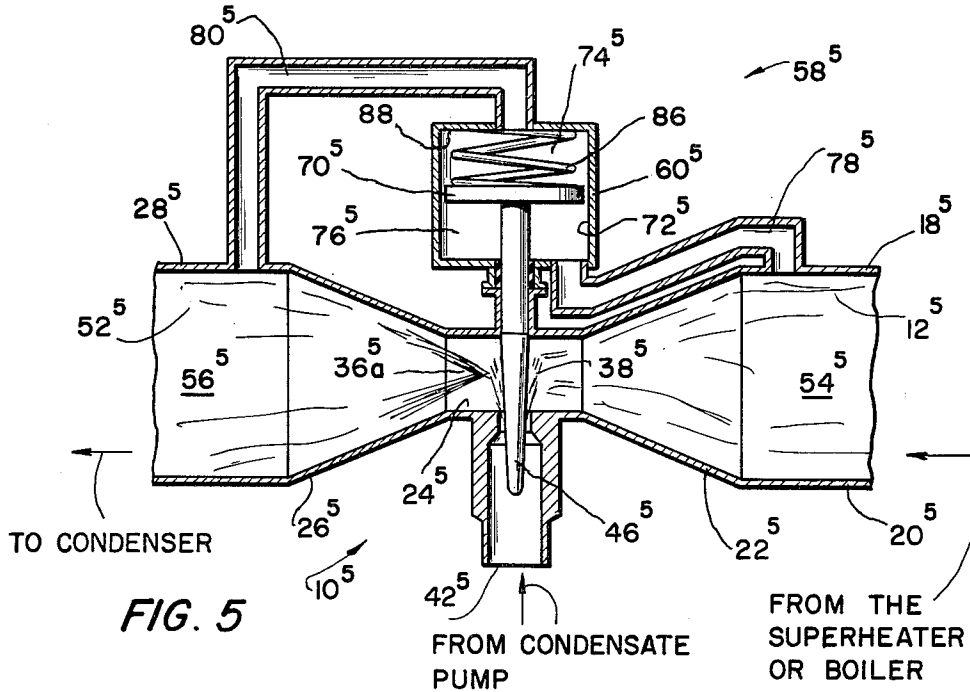
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SELF-REGULATING ATTEMPERATOR

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4 Sheets-Sheet 3



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3,220,710

SELF-REGULATING ATTEMPERATOR

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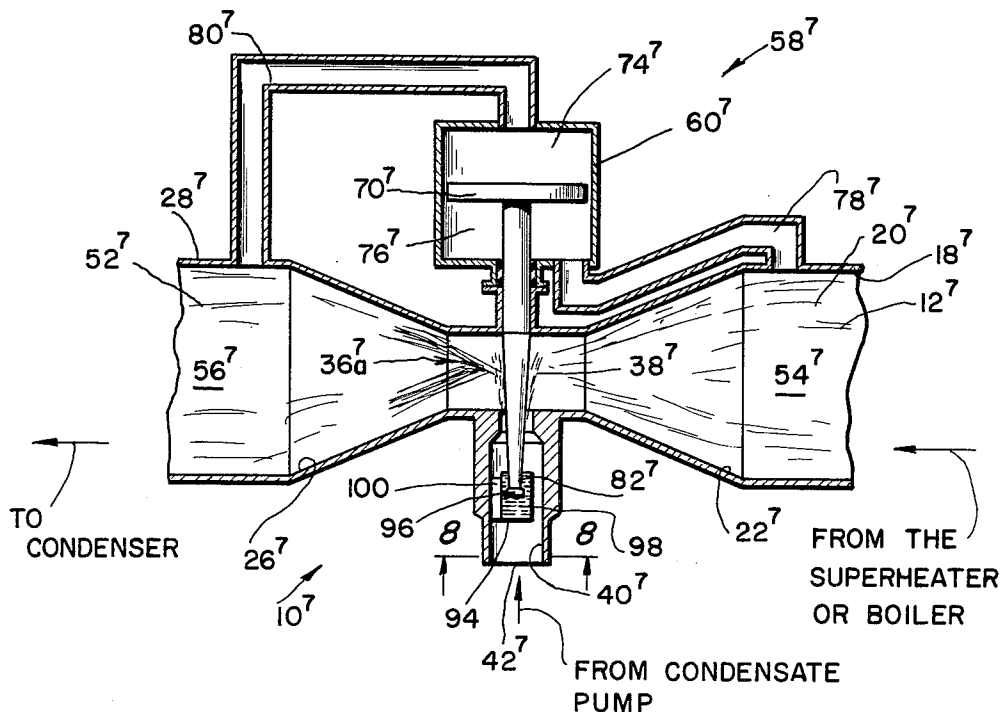


FIG. 7

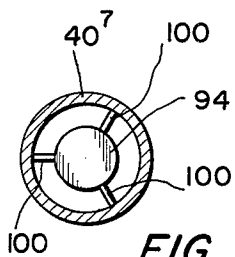


FIG. 8

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3,220,710

SELF-REGULATING ATTEMPERATOR

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4 Claims. (Cl. 261-69)

This invention relates to steam condensers and more particularly to an improved attemperator for such steam condensers and for reducing the temperature of the steam which is to be condensed.

Heretofore it has been known that steam from a boiler or a superheater is fed to a turbine where the steam drives the turbine and thereby does work. In the course of driving the turbine the temperature and the pressure of the steam is reduced. From the turbine, the used steam is exhausted into a condenser where the steam is condensed.

In the case of the occurrence of an emergency condition, such as power failure in the power plant, a safety device, such as diversion valves in the boiler and in the superheater act to discharge the steam in a dump steam line, which dump steam line by-passes the turbine and discharges the steam from the superheater, or the boiler, directly into the condenser. However, the steam in the dump steam line is hot steam capable of causing great damage to the condenser and other equipment in its path. In order to prevent the hot steam from damaging the other equipment an attemperator is provided in the dump steam line which attemperator provides an emergency supply of condensate spray to mix with the hot dump steam and to quickly reduce the temperature and the pressure of the hot dump steam to a sufficient degree thereby insuring the safety of the turbine and the condenser.

Heretofore in the attemperator art no provision has been made to regulate the flow of the condensate spray in proportion to the hot dump steam flow. The lack of regulation of the condensate spray in proportion to the hot dump steam, necessitates that the attemperator be designed for maximum dump steam flow conditions. Consequently the condensate spray flow rate at light dump steam flow leads, is far in excess of that required to reduce the temperature of the steam.

It is the general object of the present invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices by the provision of an attemperator which would automatically vary the rate of flow of the condensate spray in response and proportion to the dump steam flow rate.

Another object of the present invention is to provide an attemperator which would automatically mechanically vary the rate of flow of the condensate spray.

Still another object of the present invention is to provide an economical attemperator.

The aforesaid objects of the present invention, and other objects which will become apparent as the description proceeds, are achieved by providing an attemperator for reducing the temperature and the pressure of steam. This improved attemperator has a condensate supply means, flow means for receiving the steam, and control means operatively associated with the flow means and the supply means to control the condensate provided to the flow means.

For a better understanding of the present invention reference should be had to the accompanying drawings, wherein like numerals of reference indicate similar parts throughout the several views and wherein:

FIGURE 1, is a diagrammatic view of a condenser system incorporating the improved attemperator of the present invention therein;

FIGURE 2 is a sectional view of the improved attemperator;

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FIGURES 3 and 4 are sectional views similar to FIGURE 1 showing the travel of a piston in a control system of the attemperator;

FIGURES 5, 6 and 7 are sectional views similar to FIGURE 1 showing alternative embodiments of the present invention;

FIGURE 8 is a sectional view along the line 8-8 of FIGURE 7 in the direction of the arrows.

Although the principles of the present invention are broadly applicable to all systems embodying the reduction of the pressure and the temperature of a gaseous substance, the present invention is particularly adapted for use in conjunction with a dump steam system and hence it has been so illustrated and will be so described.

With specific reference to the form of the present invention illustrated in the drawings, and referring particularly to FIGURE 2 an attemperator is indicated generally by the reference numeral 10. In order to receive dump steam 12 from a superheater 14 or a boiler 16 (FIG. 1) the attemperator 10 is provided with a flow means, such as a steam pipe 18 (FIG. 2) having an inlet section 20, a convergent section 22, a throat section 24, a divergent section 26 and an outlet section 28 (FIG. 2). The steam pipe 18 is connected to a dump steam supply line 30 (FIG. 1) of the superheater 14 and the boiler 16 by any number of well known means 19 (FIG. 1), such as welds or threads. The dump steam supply line 30 serves as an emergency steam by-pass system for a turbine 32 (FIG. 1).

When an emergency condition, such as a power failure occurs, in order to prevent hot steam from the superheater 14 or the boiler 16 from going through the turbine 32 and damaging the turbine 32, safety devices (such as diversion valves 34, FIG. 1, located in the dump steam line 30 extending from the superheater 14 and on the boiler 16) are opened to discharge the hot steam from the superheater 14 and the boiler 16 into the dump steam supply line 30. The dump steam supply line 30 delivers the hot dump steam 12 to the pipe 18 of the attemperator 10 where the temperature and the pressure of the hot dump steam 12 are reduced before the hot dump steam 12 is discharged to a condenser 36 (FIG. 1), thus preventing the damaging of the condenser 36 by the hot dump steam 12.

The hot dump steam 12 enters the pipe 18 (FIG. 2) through the inlet section 20, flows through the convergent section 22 and is delivered to the throat section 24 where it forms a vena contracta at 36a (FIG. 2). In order to reduce the temperature and the pressure of the hot dump steam 12, it is mixed with condensate spray 38 (FIG. 2) in the throat section 24. The condensate spray 38 is supplied to the throat section 24 by a supply means, such as a condensate supply conduit 40. The condensate supply conduit 40 has a condensate spray inlet 42 at one end, which spray inlet 42 is connected to any well known apparatus, such as a pump 43 (FIG. 1) capable of supplying condensate spray 38 under pressure to the condensate supply conduit 40. The condensate spray 38 is delivered to the throat section 24, from the conduit 40, through an orifice 44 (FIG. 2).

One means for causing the conduit spray 38 to be turbulently sprayed into the throat section 24 and thus be thoroughly mixed with the hot dump steam 12, comprises variable volume means such as a needle 46 extending through the throat section 24 and the orifice 44 to reduce the annular throat area of the orifice 44 (FIG. 2) through which annular throat area the condensate spray 38 is ejected into the throat section 24. The needle 46 has a tapered outer surface 50 to aid in the ejecting of the condensate spray 38 into the throat section 24.

When the condensate spray 38 is mixed with the hot dump steam 12 in the throat section 24, it will cause the

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reduction of the temperature and the pressure of the hot dump steam 12 and thus will cause the hot dump steam 12 to become saturated dump steam 52 (FIG. 2).

The saturated dump steam 52 then flows through the divergent section 26 and the outlet section 28 where it is discharged into the dump steam outlet line 31 (FIG. 1) whereby it is delivered to the condenser 36. It will thus be understood that since the inlet section 20 is under the pressure of the hot dump steam 12 it will be under a higher pressure than the outlet section 28 which will be under the pressure of the saturated or cooled dump steam 52. Therefore, the steam pipe 18 has a high pressure area 54 in the inlet section 20 and a low pressure area 56 in the outlet section 28.

In order to regulate the amount of condensate spray 38 sprayed into the throat section 24, in proportion to the rate of steam flow flowing through the pipe 18, a control means, such as a spray control assembly 58 (FIG. 2) is provided.

Spray control assembly

The spray control assembly 58 is provided with a pressure cylinder 60 (FIG. 2), which pressure cylinder 60 has an annular extension 62 which is adapted to be connected to an annular extension 64 of the throat section 24. The annular extension 62 and the vertical annular extension 64 can be connected together by any number of ways, such as by the flanges 66, to form a tight leak proof connection.

The pressure cylinder 60 is adapted to receive the piston end 68 (FIG. 2) of the needle 46. The needle 46 extends longitudinally as shown in FIG. 2 from the condensate supply conduit 40, through the orifice 44, the throat section 24, across the annular extension 64 and the annular extension 62 and it terminates in the pressure cylinder 60. The piston end 68 of the needle 46 is connected to a piston 70 (FIG. 2) which piston 70 is disposed in the pressure cylinder 60. The piston 70 and the inner walls 72 of the pressure cylinder 60 cooperate to define a low pressure chamber 74 and a high pressure chamber 76 as shown in FIG. 2. In order to bring the high pressure chamber 76 under the influence of the pressure in the high pressure area 54 in the inlet section 20, the high pressure chamber 76 is connected to the inlet section 20 by a high pressure balance line 78 (FIG. 2). Similarly a low pressure balance line 80 connects the low pressure chamber 74 with the outlet section 28 to bring the low pressure chamber 74 under the influence of the pressure in the low pressure area 54.

Therefore, it will be understood that the high pressure chamber 76 will be at a higher pressure than the low pressure chamber 74 when dump steam 12 is flowing through the steam pipe 18. It will further be understood that as the rate of steam flow in pipe 18 increases the pressure in the inlet section 20 will increase, consequently increasing the amount of dump steam 12 and the pressure in the high pressure chamber 76. As the volume of dump steam 12 and the pressure in the high pressure chamber 76 increases the piston 70 will be lifted upwardly away from the throat section 24 of the steam pipe 18. As the piston 70 is moved upwardly from the position shown in FIG. 2 to the position shown in FIG. 3, the piston 70 will carry the needle 46 upwardly as viewed in FIG. 2. Since the needle 46 has a tapered outer surface 50 that is tapered toward its conduit end 82, as the needle 46 is moved upward, a thinner portion of the tapered outer portion 50 of the needle 46 is positioned in the orifice 44 thus increasing the annular throat area of the orifice 44 as shown in FIG. 3, to allow a greater amount of condensate spray 38 to be sprayed into the throat section 24 to mix with the hot dump steam 12.

Conversely as the flow rate of the hot dump steam 12 decreases the decreased volume and pressure of the dump steam 12 in the high pressure chamber 76 will cause the piston 70 to fall downwardly as viewed in FIG. 3 toward the steam pipe 18 from the position shown in FIG. 3 to the position shown in FIG. 4. When

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the piston 70 falls downwardly the needle 46 is moved toward the condensate supply conduit 40 to position a wider portion of the tapered outer surface 50 of the needle 46 in the orifice 44 thus reducing the annular throat area of the orifice 44 as shown in FIG. 4 to allow a lesser amount of condensate spray 38 to be sprayed into the throat section 24 to mix with the hot dump steam 12.

It will be understood by those skilled in the art that the pressure in the low pressure chamber 74 and the weight of the piston 70 can be arranged so that the pressure in the high pressure chamber 76 will position the piston 70 to control the position of the needle 46 in the orifice 44 for any range of the anticipated rate of flow of the hot dump steam 12. Thus the amount of condensate spray 38 that is sprayed into the throat section 24 to mix with the flowing hot dump steam 12, will be controlled by the hot dump steam rate of flow through the steam pipe 18.

In order to provide a leak proof connection between the pressure cylinder 60 and the throat section 24, a seal, such as packing 8, is disposed with the annular extension 62. The packing 84 rests up against the needle 46 to prevent any steam leakage from the high pressure chamber 76 to the throat chamber 24.

Operation

Even though it is believed the operation of the apparatus will be apparent from the foregoing description, a brief review of such operation will now be made for purposes of summary and simplification.

When an emergency condition, such as a power failure occurs, the diversion valves 34 located in the dump steam line 30 associated with the superheater 14 and the boiler 16 (FIG. 1) cause the hot dump steam 12 in the superheater 14 and the boiler 16 to be dumped in the dump steam line 30. The hot dump steam 12 travels in the dump steam line 30 to the attemperator 10. The hot dump steam 12 enters the attemperator 10 through the inlet section 20 and travels through the convergent section 22 to the throat section 24. The hot dump steam 12 also flows from the inlet section 20 through the high pressure balance line 78 to high pressure chamber 76 of the spray control assembly 58. The hot dump steam 12 in the high pressure chamber 76 lifts the piston 70 in the pressure cylinder 60. The motion of the piston 70 controls the position of the needle 46 in the orifice 44. The needle 46 has a tapered outer surface 50. Therefore, as the piston 70 causes the needle 46 to change its longitudinal position in the orifice 44 it will cause annular throat area of the orifice 44 to vary. Thus providing control of the supply of condensate spray 38 being fed into the throat section 24.

Condensate spray 38 is delivered to the throat section 24 through the condensate supply conduit 40, and the orifice 44. Therefore, the larger the annular throat area of the orifice 44 the greater the amount of condensate spray 38 that will be ejected into the throat section 24 to mix with the hot dump steam 12, and conversely the smaller the annular throat area of the orifice 44 the lesser the amount of condensate spray 38 that will be ejected into the throat section 24.

It will be recognized by those skilled in the art that as the rate of flow of the hot dump steam 12 is increased it will cause the piston 70 to lift from the position shown in FIG. 2 to the position shown in FIG. 3, thus lifting the needle 46 to cause the annular throat area of the orifice 44 to be increased as shown in FIG. 3. Alternatively as the rate of flow of the hot dump steam 12 is decreased, it will cause the piston 70 to fall from the position shown in FIG. 3 to the position shown in FIG. 4 thus lowering the needle 46 to cause a decrease in the annular throat area of the orifice 44 as shown in FIG. 4. Therefore, it is understood that the rate of flow of the hot dump steam 12 is the attemperator 10 will control the amount of condensate spray 38 that will be sprayed into the throat section 24.

When the condensate spray 38 is mixed with the hot

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dump steam 12, such mixture will reduce the hot dump steam 12 to saturated dump steam 52 having a lower pressure and a lower temperature than the hot dump steam 12. The saturated dump steam 52 is then discharged from the attemperator 10 into dump steam outlet line and is delivered to the condenser 36.

Alternative embodiments

It will be understood by those skilled in the art that alternatively as shown in FIG. 5 a spring 86 is disposed in the pressure cylinder 60⁵ in the chamber 74⁵. The spring 86 rests between the upper horizontal wall 88 of the pressure cylinder 60⁵ and the piston 70⁵. The spring 86 serves to prevent a sudden thrust of the piston 70⁵ and of the needle 46⁵ in the case of a sudden increase of steam flow in the steam pipe 18⁵ or in the case of the initial burst of steam flow in the steam pipe 18⁵. In addition the spring 86 will also provide a finer control for the travel of the piston 70⁵ and the needle 46⁵.

Further alternatively as shown in FIG. 6 uniform motion means, such as the vertical walls 90 of the pressure cylinder 60⁶ and the vertical walls 92 of the piston 70⁶ being tapered slightly, are provided in order to provide a more linear, uniform, and smoother movement of the needle 46⁶.

Still further alternatively as shown in FIGURES 7 and 8 in order to smooth, stabilize and limit the travel of the needle 46⁷ to a prescribed maximum and minimum a uniform motion means, such as a dash pot 94 is disposed in the condensate spray conduit 40⁷. The conduit end 82⁷ of the needle 46⁷ is disposed in the dash pot 94. In addition the conduit end 82⁷ is provided with a piston 96 (FIG. 7) which piston 96 rests in a liquid 98, such as oil, disposed in the dash pot 94. The action between the piston 96 and the liquid 98 will result in a more stabilized, uniform, better controlled, needle motion. As shown in FIG. 8 the dash pot 94 can be connected to the conduit 40⁷ by way number of ways such as angle strips 100, in order not to obstruct the flow of conduit 40⁷.

It will be recognized by those skilled in the art that the objects of the present invention have been achieved by providing an attemperator which automatically varies the rate of flow of the condensate spray in response and proportion to the dump steam flow rate. The attemperator mechanically varies the flow rate and provides for a more economical efficient operation.

While in accordance with the patent statutes a preferred embodiment of the present invention has been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

I claim:

1. An attemperator for reducing the temperature and the pressure of flowing steam comprising:

- (a) a pipe for receiving said steam;
- (b) said pipe being provided with an inlet section for receiving said steam, a converging section disposed adjacent to and communicating with said inlet section reducing the volume of said steam, a throat section disposed adjacent to and communicating with said converging section for causing said steam to reach a vena contracta, a diverging section disposed adjacent to and communicating with said throat section to expand said steam, and an outlet section disposed adjacent to and communicating with said diverging section to discharge said steam from said pipe,

(1) said steam cooperating with said inlet section and said converging section and said throat section and said diverging section and said outlet section to create a pressure differential between said inlet section and said outlet section;

(c) a conduit having two ends and adapted to be connected at one of said ends to a source of condensate spray and having the other of said ends communicat-

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ing with said throat section to supply condensate spray to said throat section;

- (1) said other end of said conduit terminating in an orifice;
 - (d) a pressure cylinder having side walls and being connected to said throat section;
 - (e) a piston disposed in said cylinder;
 - (f) said piston cooperating with said side walls of said pressure cylinder to form two pressure chambers;
 - (g) first conduit means connecting one of said pressure chambers to said inlet section to put said pressure chamber under the influence of the pressure in said inlet section,
 - (h) second conduit means connecting the other of said pressure chambers to said outlet section to put said other pressure chamber under the influence of the pressure in said outlet section;
 - (i) a needle attached to said piston and extending through said throat section and through said orifice,
 - (j) said needle being reciprocated by said piston to vary the flow area of said orifice.
2. An attemperator for reducing the temperature and the pressure of flowing steam comprising:

- (a) a pipe for receiving said steam;
- (b) said pipe being provided with an inlet section for receiving said steam, a converging section disposed adjacent to and communicating with said inlet section reducing the volume of said steam, a throat section disposed adjacent to and communicating with said converging section for causing said steam to reach a vena contracta, a diverging section disposed adjacent to and communicating with said throat section to expand said steam, and an outlet section disposed adjacent to and communicating with said diverging section to discharge said steam from said pipe,

(1) said steam cooperating with said inlet section and said converging section and said throat section and said diverging section and said outlet section to create a pressure differential between said inlet section and said outlet section;

(c) a conduit having two ends and adapted to be connected at one of said ends to a source of condensate spray and having the other of said ends communicating with said throat section to supply condensate spray to said throat section,

(1) said other end of said conduit terminating in an orifice having a reduced horizontal flow area to cause said condensate spray to be turbulently ejected in said throat section;

(d) a pressure cylinder having side walls and being connected to said throat section;

(e) a piston disposed in said cylinder;

(f) said piston cooperating with said side walls of said pressure cylinder to form two pressure chambers;

(g) first conduit means connecting one of said pressure chambers to said inlet section to put said pressure chamber under the influence of the pressure in said inlet section;

(h) second conduit means connecting the other of said pressure chambers to said outlet section to put said other pressure chamber under the influence of the pressure in said outlet section;

(i) a needle attached to said piston and extending through said throat section and through said orifice;

(1) said needle being provided with a tapered outer surface;

(j) said needle being reciprocated by said piston to vary the flow area of said orifice.

3. An attemperator for reducing the temperature and the pressure of flowing steam comprising:

(a) a pipe for receiving said steam;

(b) said pipe being provided with an inlet section for receiving said steam, a converging section disposed

adjacent to and communicating with said inlet section reducing the volume of said steam, a throat section disposed adjacent to and communicating with said converging section for causing said steam to reach a vena contracta, a diverging section disposed adjacent to and communicating with said throat section to expand said steam, and an outlet section disposed adjacent to and communicating with said diverging section to discharge said steam from said pipe,

- (1) said steam cooperating with said inlet section and said converging section and said throat section and said diverging section and said outlet section to create a pressure differential between said inlet section and said outlet section;
- (c) a conduit having two ends and adapted to be connected at one of said ends to a source of condensate spray and having the other of said ends communicating with said throat section to supply condensate spray to said throat section;
 - (1) said other end of said conduit terminating in an orifice;
- (d) a pressure cylinder having side walls and being connected to said throat section;
- (e) a piston disposed in said cylinder;
- (f) said piston cooperating with said side walls of said pressure cylinder to form two pressure chambers;
- (g) first conduit means connecting one of said pressure chambers to said inlet section to put said pressure chamber under the influence of the pressure in said inlet section,
- (h) second conduit means connecting the other of said pressure chambers to said outlet section to put said other pressure chamber under the influence of the pressure in said outlet section;
- (i) a needle attached to said piston and extending through said throat section and through said orifice;
- (j) said needle being reciprocated by said piston to vary the flow area of said orifice; and
- (k) a uniform motion means operatively associated with said needle for maintaining uniform smooth motion during said needle reciprocation.
4. An attemperaturator for reducing the temperature and the pressure of flowing steam comprising:
 - (a) a pipe for receiving said steam;
 - (b) said pipe being provided with an inlet section of uniform cross section for receiving said steam, a converging section disposed adjacent to and communicating with said inlet section for reducing the volume of said steam, a throat section disposed adjacent to and communicating with said converging

section for causing said steam to reach a vena contracta, a diverging section disposed adjacent to and communicating with said throat section to expand said steam, and an outlet section of uniform cross section disposed adjacent to and communicating with said diverging section to discharge said steam from said pipe,

- (1) said steam cooperating with said inlet section and said converging section and said throat section and said diverging section and said outlet section to create a pressure differential between said inlet section and said outlet section;
- (c) a conduit having two ends and adapted to be connected at one of said ends to a source of condensate spray and having the other of said ends communicating with said throat section to supply condensate spray to said throat section,
 - (1) said other end of said conduit terminating in an orifice;
- (d) a pressure cylinder having side walls and being adjacent said throat section;
- (e) a piston disposed in said cylinder;
- (f) said piston cooperating with said side walls of said pressure cylinder to form two pressure chambers;
- (g) first conduit means connecting one of said pressure chambers to said inlet section to put said pressure chamber under the influence of the pressure in said inlet section;
- (h) second conduit means connecting the other of said pressure chambers to said outlet section to put said other pressure chamber under the influence of the pressure in said outlet section;
- (i) a needle attached to said piston and extending into said conduit for controlling the flow of condensate spray through said orifice;
- (j) said needle being reciprocated by said piston to vary the flow area of said orifice.

References Cited by the Examiner

UNITED STATES PATENTS

1,832,652	11/1931	Peebles	122—479
2,207,646	7/1940	Ploeg	122—459

FOREIGN PATENTS

792,970	11/1935	France.
156,854	1/1921	Great Britain.
452,187	8/1936	Great Britain.

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