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T. A. PEEBLES
METHOD AND APPARATUS FOR THE REGULATION OF
THE TEMPERATURE OF SUPERHEATED STEAM
Filed Sept. 8, 1930

1,832,652

2 Sheets-Sheet 1

Fig. 1.

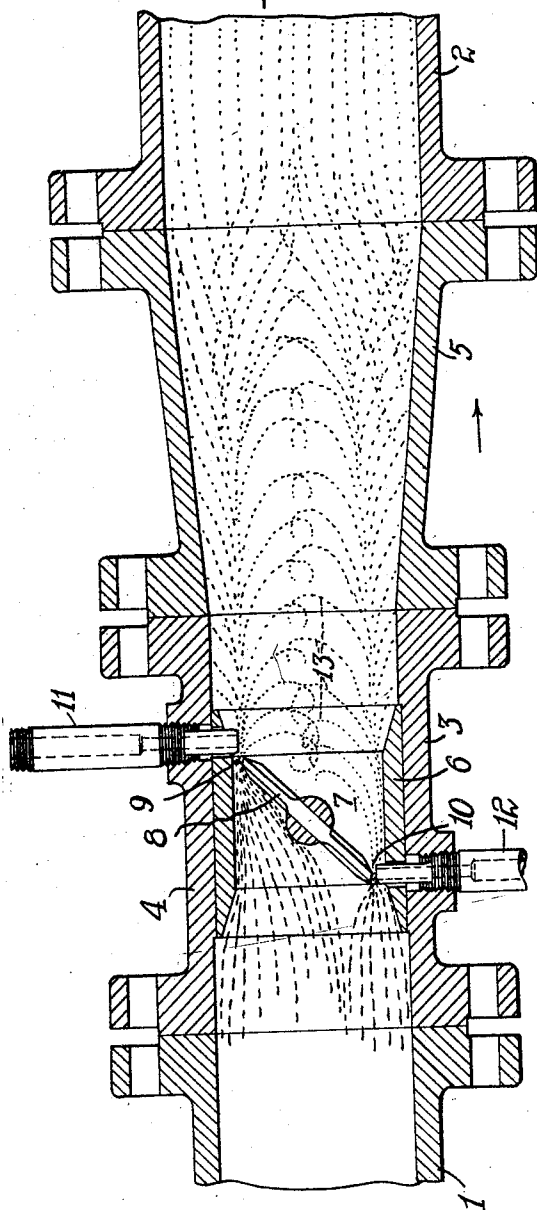
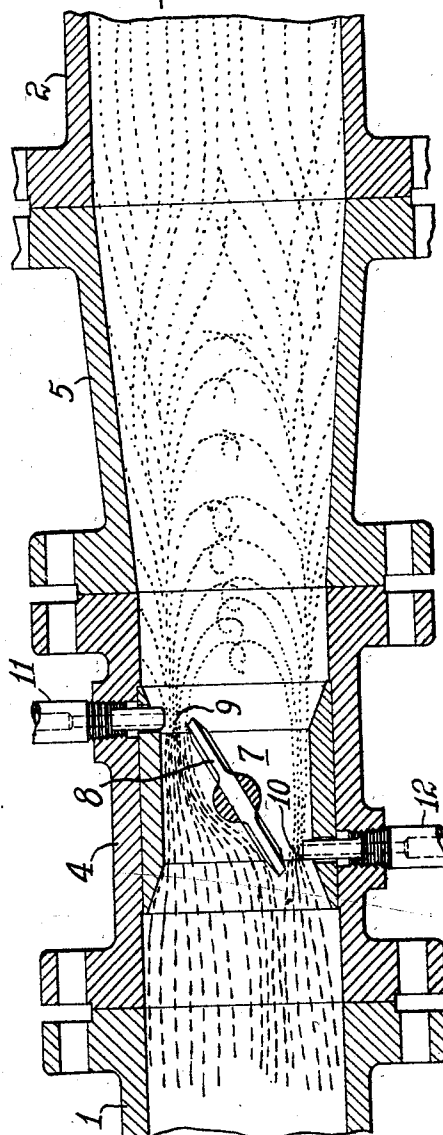


Fig. 2.



INVENTOR

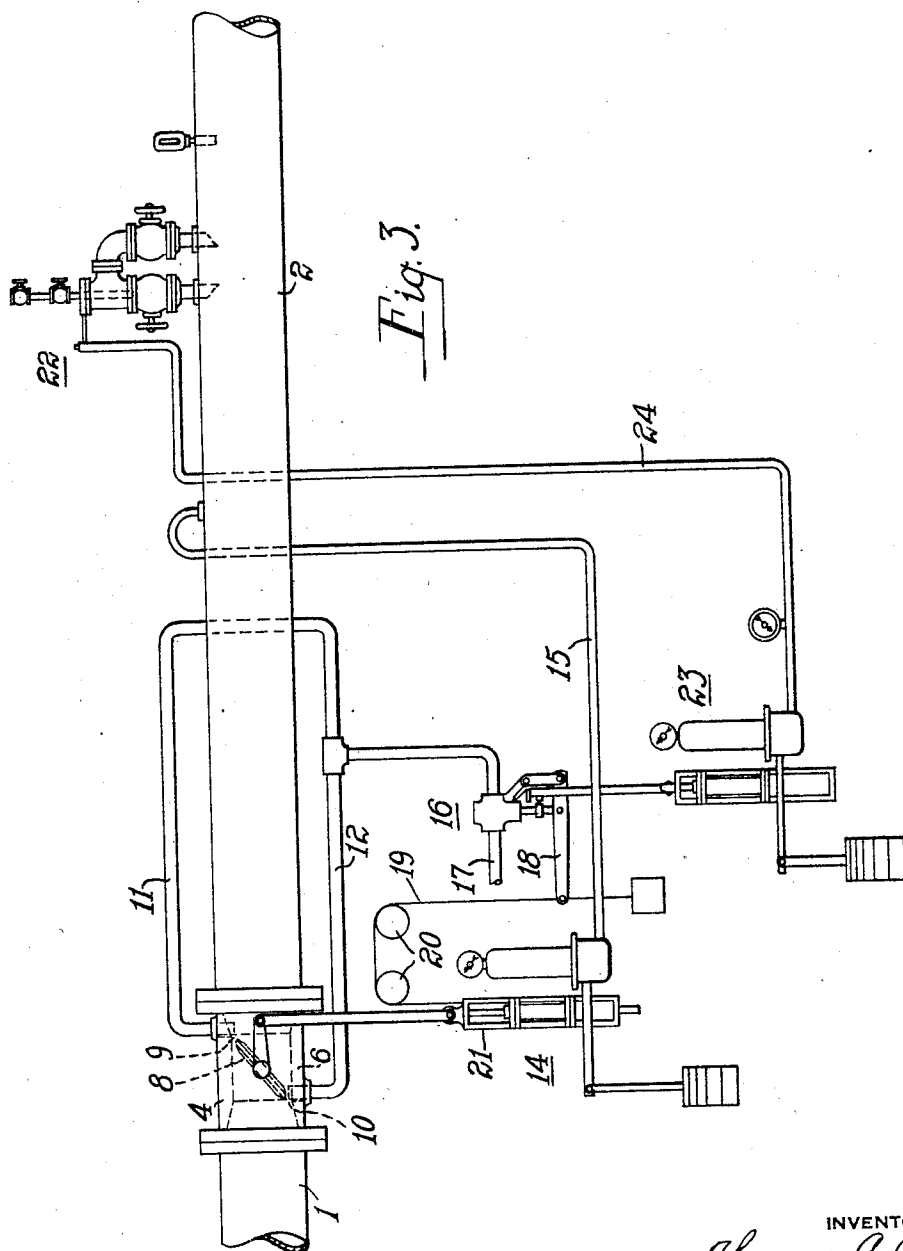
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By Green & McCallister
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UNITED STATES PATENT OFFICE

THOMAS A. PEEBLES, OF MOUNT LEBANON, PENNSYLVANIA, ASSIGNOR TO JOHN M. HOPWOOD, OF DORMONT, PENNSYLVANIA

METHOD AND APPARATUS FOR THE REGULATION OF THE TEMPERATURE OF SUPERHEATED STEAM

Application filed September 8, 1930. Serial No. 430,481.

This invention relates to steam flow systems having reduced pressure lines and more particularly to the art of de-superheating the steam in the reduced pressure systems.

Heretofore, it has been the practice to employ a Venturi throat in which the flow of steam acts to induce a flow of water into the steam to be de-superheated. In other cases, spray rings having a plurality of fine openings through which water flows into the stream of steam have been used. There have been cases also where water has been introduced into the steam through a spray nozzle and the flow of water regulated in accordance with requirements.

Any of the devices referred to above operate satisfactorily so long as large quantities of steam are flowing because the velocity of the steam is sufficient to thoroughly atomize the water so that it will mix properly with the steam.

For low rates of steam flow, the above devices are not satisfactory because the steam velocity is insufficient to produce proper atomization and mixing of the water. In those cases where the spray ring or spray nozzle is employed, the small quantity of water required for de-superheating the small quantity of steam, flows through the spray ring or nozzle without being thoroughly broken up or atomized before entering the steam line.

It is well known that when steam flows from a region of high pressure to a region of low pressure, its velocity is dependent upon the pressure and temperature conditions of the steam in both the high and low pressure regions. This velocity tends to increase as the difference in pressure between the high pressure and the low pressure regions becomes greater, until a critical point is reached beyond which the velocity of the steam flow will not increase. This critical point is reached when the pressure in the low pressure region is less than 58 per cent of the

pressure in the high pressure region. When this point is reached no appreciable increase in velocity takes place even though the differential in pressure is increased. For ordinary conditions, this maximum velocity is very high. Where a pressure reducing valve is employed to create this differential in pressure, it will be apparent that the velocity flow of the steam through the restricted areas of the valve will remain constant for a given pressure drop across the valve. For example, if steam in the high pressure line is at a pressure of 400 pounds per square inch and it is desired to reduce the pressure to 250 pounds per square inch in the low pressure system or line, the velocity of the steam flowing through the valve will remain substantially constant, varying slightly with slight variations of pressure in the two lines or systems. But for any given set of pressures, this velocity will remain substantially constant.

Suppose the demand for steam is reduced to one-half of a previous demand, and that the pressure in the whole pressure system or line is being controlled at a predetermined value by a pressure regulating device. In such a case, the regulating device operates until the valve has been adjusted so that its flow area is equal to one-half its previous flow area. For either position of the valve and for each flow area, the velocity of the steam through it will be the same. Since the velocity of the steam through the valve remains constant, the flow area of the valve must be varied in direct proportion to the quantity of steam flowing through it. Therefore, if water for de-superheating purposes is delivered to the steam line at the point where the greatest valve restriction takes place, the water will always be brought in contact with the steam at that point where the steam velocity is highest and where this velocity is practically constant regardless of the quantity of steam flowing. For this reason the

water will be efficiently atomized and thoroughly mixed with the steam to be de-superheated.

An object of this invention is to establish a differential pressure between a high pressure and a reduced pressure system that will give a high velocity of steam flow for substantially all quantities or volumes of steam flowing through the systems.

Another object of the invention is to provide for de-superheating steam in a reduced pressure line or system by introducing de-superheating fluid into the steam at a point in the system where the steam is flowing at a high velocity.

A further object of the invention is to provide for introducing de-superheating fluid into a steam line having high and reduced pressure sections, at a point between the sections where the velocity of the steam is substantially constant for all values of quantity steam flow.

Other objects of the invention will, in part, be apparent, and will, in part, be obvious from the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a partial view in longitudinal section of a steam line having high and low pressure sections, having means embodied therein arranged and constructed in accordance with the invention for de-superheating the steam in the low pressure sections and a valve for controlling the quantity of steam flow from the high to the low pressure section;

Fig. 2 is a similar view showing the valve in a position to permit a larger volume of steam to flow than in Fig. 1; and

Fig. 3 is a diagrammatic illustration of a system for controlling the amount of de-superheating liquid delivered in accordance with pressure and temperature conditions existing in some selected section of a steam distribution line.

Throughout the drawings and the specification like reference characters indicate like parts.

In the drawings, a high pressure steam line or system 1 and a low pressure system or steam line 2 are shown. The lines or sections 1 and 2 are connected by a conduit or pipe 4 and a conduit 5. Since high pressure steam lines are usually of smaller diameter than the low pressure steam lines, the conduit 5 is of funnel or cone shape so that the flow areas of the section 1 and the conduit 3 will gradually merge into the flow area of the pipe line or section 2 by means of the conduit 5.

The conduit 3 is provided with an internal sleeve 6 having a reduced area 7 that forms a Venturi throat between the high and low pressure sections. In order that the quantity of steam flowing through the Venturi throat 7 may be controlled, a valve 8 is provided.

If it be assumed that the pressure in the steam line 1 is at 400 pounds per square inch and that the pressure is to be reduced in the low pressure line to a value of approximately 165 pounds per square inch, then the pressure in the reduced pressure line 2 will be less than 58 percent of the pressure in the high pressure section 1. When the pressure in the low pressure section is less than 58 percent of the pressure in the high pressure section, the velocity of the steam through the Venturi throat will be approximately 1550 feet per second. This velocity is generally called the critical velocity of steam flow through a restricted area, and this velocity will not increase even though the pressure differential between the high and low pressure sections is increased by decreasing the pressure in the reduced pressure line or system.

Assuming that the above pressures exist in the high and low pressure sections, then if the valve 8 occupies the position shown in Fig. 1, the velocity of the steam flowing through the valve at points 9 and 10 will be about 1550 feet per second. This velocity of the steam is very effective for efficiently atomizing water introduced at points adjacent valve openings 9 and 10. Water or fluid admitted adjacent these valve openings will be thoroughly atomized and mixed with the steam flowing to the low pressure sections so that the steam temperature may be controlled at any desired value according to the amount of water introduced.

In the present form of the invention, water for de-superheating purposes is admitted to the Venturi throat 7 through lines 11 and 12. The water admitted through the lines 11 and 12 is discharged at a point adjacent to the valve openings 9 and 10 and on the downstream side thereof. When the steam flowing through the valve openings 9 and 10 impinges on or strikes the streams of water discharging into the throat 7 from the lines 11 and 12, a series of turbulent eddy currents are set up as indicated by the broken lines 13 causing the water which has been atomized by the high velocity steam, to be thoroughly and intimately mixed with the steam before it enters the reduced pressure line 2.

In Fig. 2 of the drawings, valve 8 is open wider than in Fig. 1 in order that a larger volume or quantity of steam may flow to the low pressure line. Since, however, the pressure in line 2 is maintained at about 58 percent of the pressure in the high pressure line 1, the velocity of the steam through the valve openings 9 and 10 will remain the same as in Fig. 1, that is, at the critical value. Since the velocity remains the same in either case, whether the valve is only partially open, as in Fig. 1, or much farther open, as in Fig. 2, the velocity of the steam will be sufficient to effect complete atomizing and mixing

of the water with the steam flowing to the reduced pressure line 2.

It will be observed that the water lines 11 and 12 discharge water into the Venturi throat 7 at points where the area through which steam may flow is most affected by the valve 8. Therefore, the highest velocity of steam is available to atomize the water admitted for de-superheating purposes.

The valve 8 and the quantity of water admitted into the Venturi throat 7 through lines 11 and 12 may be controlled in accordance with the pressure and temperature of the steam in the reduced pressure line 2 and also in accordance with the quantity of steam flowing through this section. One form of such a control system is disclosed in my United States Letters Patent No. 1,794,028 granted February 24, 1931, and assigned to John M. Hopwood.

It has been found that where pressure reduction is involved in steam lines of the type disclosed in the drawings, velocities of from 1000 to 1550 feet per second take place through the valve openings and velocities such as these are ample to efficiently and thoroughly atomize water when introduced into the steam in the manner disclosed herein.

In Fig. 3 an arrangement is illustrated for controlling the pressure and temperature of the steam traversing one section of the steam line, as for example, the low pressure section of line 2.

To control the amount of steam delivered to the low pressure section, so as to thereby regulate the pressure of the steam therein, a regulator 14 is provided for adjusting valve 8 to such positions as are required to maintain the pressure in section 2 at some predetermined value. Regulator 14 may be of the pressure responsive type illustrated in United States Letters Patent No. 1,371,243 granted to John M. Hopwood. The pressure element of this regulator is connected by a pipe 15 to the low pressure section 2 of the system.

If the pressure in section or line 2 rises above a predetermined value, regulator 14 responds and adjusts valve 8 towards its closed position until the pressure is reduced to such value; or if the pressure falls, the valve is actuated towards its open position until the pressure in line 2 is increased to said predetermined value.

In order to proportion the amount of water or de-superheating fluid admitted into the restricted passageway 7, in accordance with the position of valve 8, and hence in proportion to the amount of steam delivered to line 2, a valve 16 is provided and arranged to be operated by regulator 14. Valve 16 is located in a supply line 17 having de-superheating fluid, such as water, therein at the proper pressure. The discharge side of valve 16 serves fluid delivery pipes 11 and 12.

Valve 16 has an operating lever 18 connected by a cable 19 running over suitable pulleys 20 to a movable frame 21 of regulator 14. Thus, as the regulator operates to open or close a valve 8, valve 16 is correspondingly opened or closed.

In some instances, the pressure in the low pressure section may be at the desired value, but the temperature of the steam may not be at the proper value. Thus, if the temperature is too high, more de-superheating fluid should be admitted into the steam; or if too low, the amount of water should be reduced.

Therefore, to provide for regulating the amount of de-superheating fluid admitted to the steam in accordance with the temperature thereof in section 2, a temperature responsive device 22 and a regulator 23 are employed to affect adjustments in valve 16 in addition to those occasioned by regulator 14. Regulator 23 and device 22 may be constructed as illustrated in my Patent No. 1,794,028, the regulator being like regulator 14 herein illustrated.

Thus, regulator 14 operates to adjust valve 16 in accordance with variations in pressure in section or line 2 and regulator 23 and temperature responsive device 22 cooperate to make such further adjustments that the amount of water or de-superheating fluid delivered to the steam at the point in restricted section 7 where the velocity of the steam is a maximum.

As described in my Patent No. 1,794,028, changes in temperature in the steam in line 2 are converted into pressure variations. These pressure variations are communicated to regulator 23 by a pipe line 24.

While various modifications and changes may be made in the apparatus herein disclosed without departing from the spirit and the scope of the invention, it is to be understood that only such limitations shall be placed on the invention as are imposed by the prior art and the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. The method of de-superheating steam in a system where steam flows from a high pressure to a low pressure line that consists in creating a restricted flow area between said pressure lines, dividing the flow through the restricted area into two streams and introducing de-superheating fluid into said divided streams at the points of maximum velocity therein.

2. The method of de-superheating steam in a system where steam flows from a high pressure to a low pressure line that consists in creating a restricted flow area between said pressure lines, dividing the flow through the restricted area into two streams introducing de-superheating fluid into said divided streams at the points of maximum velocity therein and proportioning the quantity of de-

superheating fluid in accordance with the quantity of steam flowing through said pressure line.

3. The method of de-superheating steam in a system where steam flows from a high pressure to a low pressure line that consists in creating a restricted flow area between said pressure lines, dividing the flow to said restricted area into a plurality of streams, and introducing de-superheating fluid into said streams at the points of maximum velocity therein.

4. The method of de-superheating steam in a system where steam flows from a high pressure to a low pressure line that consists in creating a restricted flow area between said pressure lines, dividing the flow to said restricted area into a plurality of streams, introducing de-superheated fluid into said streams at the points where the velocity therein is maximum and proportioning the quantity of de-superheating fluid introduced into said streams in accordance with the quantity of steam flowing through said lines.

5. The method of de-superheating steam in a system where steam flows from a high pressure to a low pressure line that consists in creating a restricted flow area between said pressure lines, dividing the flow to said restricted area into a plurality of streams, introducing de-superheating fluid into said streams where the velocity therein is a maximum and proportioning the quantity of de-superheating fluid introduced into said streams directly in accordance with the quantity of steam flowing through said lines.

6. The method of de-superheating steam in a reduced pressure line that consists in creating a pressure differential between the high and low pressure lines such as will create a critical velocity in the flow of steam through the region effecting said pressure reduction and in introducing de-superheating fluid into the steam flowing through said region at a critical velocity.

7. The method of de-superheating steam in a reduced pressure line that consists in establishing a critical velocity in the steam flowing into the low pressure line and introducing de-superheating fluid into the steam flowing at said critical velocity.

8. The method of de-superheating steam in a reduced pressure line that consists in establishing a critical velocity in the steam flowing into the low pressure line and introducing water into the stream flowing at said critical velocity.

9. In combination with a high and low pressure steam line having a reduced flow section at the junction of said lines, of a valve in said section for varying the flow area there-through, and means for introducing de-superheating fluid into said section at the point where the flow area is most affected by said valve.

10. In combination with a high and low pressure steam line having a reduced flow section at the junction of said lines, of a valve in said section for varying the flow area there-through, means for introducing de-superheating fluid into said section at the point where the flow area is most affected by said valve, and means for proportioning the de-superheating fluid introduced to said section in accordance with the quantity of steam flowing therethrough and the temperature of the steam in one of said sections.

11. The method of de-superheating steam which consists in establishing a constant high velocity in steam flowing to a reduced pressure line which velocity is independent of the quantity of steam flowing and in introducing water into the steam at the point of maximum velocity.

12. The method of producing an intimate mixture of steam and water for de-superheating purposes, that consists in so controlling a restriction between a high and a low pressure steam line that a substantially constant high velocity flow is maintained in the restriction and then in admitting water to the restriction at the point where the velocity of said steam flow is substantially constant.

13. The method of producing an intimate mixture of steam and water for de-superheating purposes, that consists in so controlling a restriction between a high and a low pressure steam line that a substantially constant high velocity flow is maintained in the restriction, admitting water to the restriction at the point where the velocity of said steam flow is substantially constant, measuring the temperature and pressure of the steam in one of said lines, and then in controlling the amount of steam flowing through the restriction in accordance with said measurements.

14. In combination with a high and low pressure steam line having a reduced flow section at the junction of said lines, of a valve in said section for varying the flow area there-through, means for introducing de-superheating fluid into said section at the point where the flow area is most affected by said valve, and means for controlling said valve and the amount of de-superheating fluid delivered to said section in accordance with the temperature and pressure of the steam in one of said lines.

15. In combination, a steam line having a restriction therein, a valve in said restriction, and means for introducing de-superheating fluid into said restriction at a point therein where the flow area is most affected by said valve.

16. In combination, a steam line having a restriction therein, a valve in said restriction, and means for introducing de-superheating fluid into said restriction at a plurality of diametrically opposed points therein where the flow area is most affected by said valve.

17. In combination, a steam line having
a restriction therein, a valve in said restric-
tion, means for introducing de-superheating
fluid into said restriction at a plurality of
5 diametrically opposed points therein where
the flow area is most affected by said valve,
and means for controlling said valve and
the amount of de-superheating fluid intro-
duced in accordance with the pressure and
10 temperature of the steam at a point in said
line remote to said restriction.

In testimony whereof, I have hereunto sub-
scribed my name this 6th day of September,
1930.

THOMAS A. PEEBLES.