June 25, 1957 F. B. SCHNEIDER 2,796,949

VORTEX STEAM SEPARATOR

Filed Dec. 27, 1954

Fig. 1.

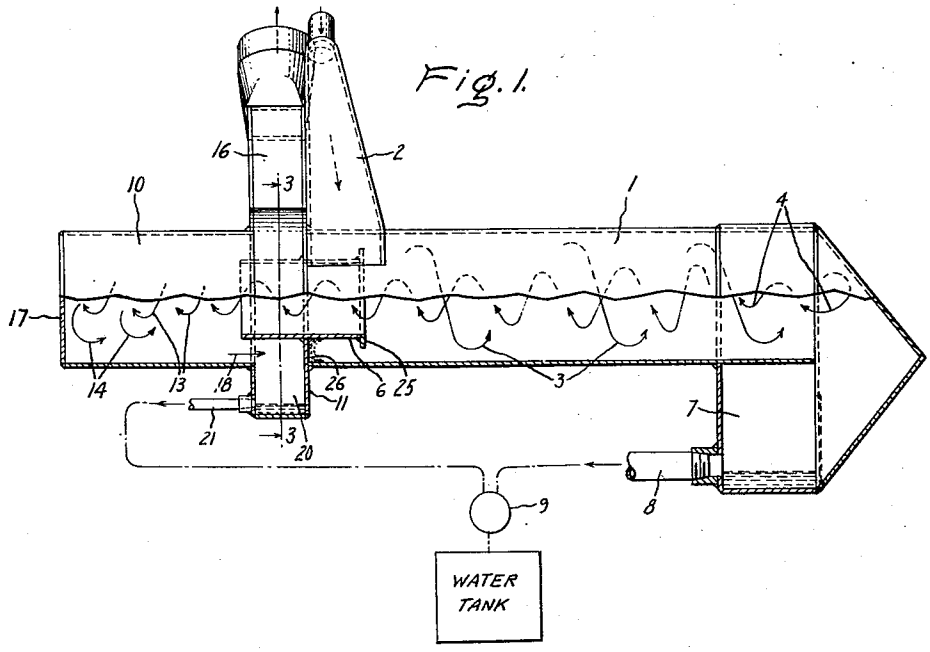


Fig. 2.

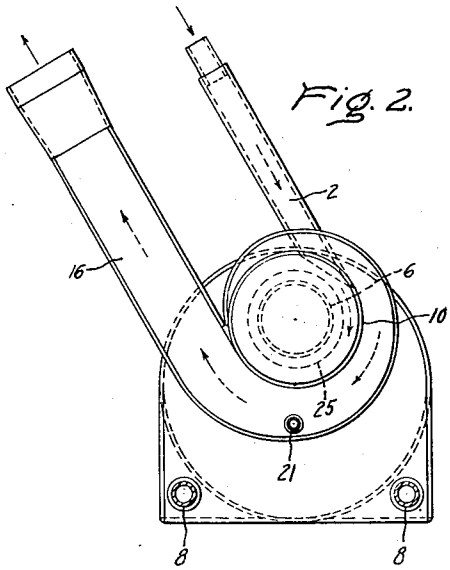
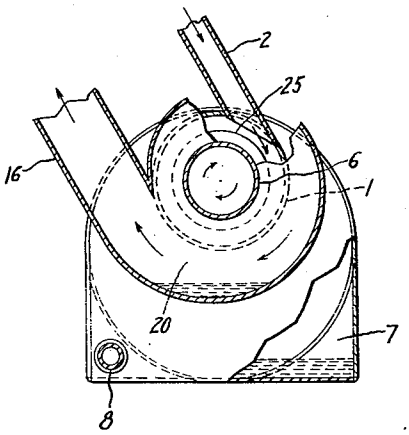


Fig. 3.



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VORTEX STEAM SEPARATOR

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1 Claim. (Cl. 183—34)

My invention relates to steam-separating devices and more particularly to a vortex steam separator for drying supersaturated steam with an arrangement for recovering part of the pressure drop which is lost in passing through the separator, such that the exhaust pressure of the steam is substantially the same as the intake pressure.

For many years in the art of steam separators, particularly steam separators on locomotives, industry has been searching for an efficient device adaptable for use in a space which is often restricted vertically. In such a restricted space, a separator of a type that is relatively long must be mounted horizontally. Many steam separators are not adaptable to efficient operation in a horizontal position. Another severe problem with steam separation is that the separator must exhaust the steam at low pressures. If the pressure of the exhaust is substantially reduced compared to the pressure of the inlet steam to the steam separator, the exhaust may carry a considerable amount of water vapor. If the steam pressure at the exhaust is increased to the approximate inlet steam pressure, the exhaust steam is super heated.

Therefore, the object of my invention is to provide a steam separator with an arrangement for recovering the pressure of the steam such that the exhaust pressure is substantially the same as the intake pressure of the steam.

A further object of my invention is to provide a steam separator which can be mounted vertically or horizontally without reduction of its efficiency.

Further objects and advantages of my invention will become apparent and my invention will be better understood from the following description referring to the accompanying drawings. The features of novelty which characterize my invention will be pointed out with particularity in the claim annexed to and forming part of this specification.

In the drawings, Fig. 1 is a side elevation view of a vortex steam separator device illustrating one embodiment of my invention.

Fig. 2 is a plan view of the device shown in Fig. 1; and

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 1.

Referring to the drawings, in Fig. 1, I have shown one embodiment of my improved steam separator and special recovery device in connection with a vortex steam separator. The steam drier illustrated is the type which uses a drying cylinder 1 having an inner diameter of approximately 15 inches and a length a multiple of 3 to 50 times the diameter of the cylinder 1. In the free vortex steam separator, the incoming super saturated steam is blown through a tangentially arranged inlet pipe 2, which introduces the steam to be dried substantially tangentially to the cylinder 1 near one end thereof. The pipe 2 is located adjacent to one end of the cylinder 1 and adjacent to the inner peripheral wall of the cylinder, as more clearly shown in Figs. 2 and 3. This creates a swirl or free vortex of the super saturated steam in the drying cylinder 1, the outer of circumferential part of which spirals to the right, as indicated by the arrows 3, along the wall of the cylinder adjacent to the inner surface, while the steam in the center spirals to the left around the axis of the cylinder as indicated by the arrows 4, with the apex of the vortex adjacent to the cylindrical transfer tube 6, thereby converting a susbtantial portion of the

static pressure head of the introduced supersaturated steam into a velocity head. By this movement of the steam, water is ejected from the steam against the inner surface of the drying cylinder 1 and flows to the receiving tank 7 arranged at the right-hand end and below the axis of vortex for collection and removal of the entrapped water through the pipe outlet 8, by means such as a vacuum pump 9 which deposits the extracted water in a tank or reservoir.

It is a well-known phenomenon that if dry and saturated steam is exhausted into the atmosphere it becomes immediately supersaturated and condenses a large percentage of water. On the other hand, if superheated steam of sufficiently higher pressure is exhausted into the atmosphere, it remains dry and superheated. Therefore, it is desirable to recover as much as possible of the pressure losses which might occur in the free vortex steam separator. In order to reconvert the velocity head of the dried steam into pressure head, I provide a second cylinder 10 arranged axially with the cylinder 1 to provide a pressure recovery arrangement. This pressure recovery cylinder 10 is arranged adjacent to the drying cylinder 1 and has substantially the same diameter as the drying cylinder 1 with a length a multiple of and at least twice this diameter. The cylinder 10 does not need to be as long as the cylinder 1, because of the fact it is to stop the free vortex, instead of create it.

It is preferred that relatively small diameter transfer tube 6 which should not be of a diameter greater than two-thirds the diameter of the drying cylinder 1 extends through the orifice in the center of the annular end plate 11 between the cylinders 1 and 10. In order that the apex of the free vortex is not destroyed, the transfer tube 6 must be unrestricted and is preferably circular as shown in Fig. 3. This arrangement creates a complementary vortex in the pressure recovery cylinder 10 with its apex adjacent to the transfer tube 6, where the steam is rotating rapidly as shown by the arrows 13 and at the same time spiraling toward the left as it leaves the transfer tube 6. The path of the rotating column of steam follows the pattern shown generally by the arrows 14. The vortex in the pressure recovery cylinder 10, therefore, resembles an expanding flared cone-shaped column of rapidly rotating super heated steam, wherein the steam expands due to the centrifugal force to the inner surface of the recovery cylinder 10 and is forced to the right by the end plate 17 toward the tangential exhaust tube 16. The swirling steam as indicated by the arrows 13 and 14 is deflected by the end plate 17 of the pressure recovery cylinder 10 into a rotating, rightwardly moving column tangential to the inner surface of the pressure recovery cylinder 10 and into the region of the tangential exhaust pipe 16, as shown by the arrow 18 in Fig. 1.

The spiral flow from the small diameter transfer tube 6 to the larger diameter of the pressure recovery cylinder 10 reconverts the velocity head of the steam introduced into the pressure recovery cylinder 10 by the transfer tube 6 into a pressure head which is substantially equal to the static steam pressure at the inlet pipe 2. The exhaust pipe 16 communicates with a peripheral passage or opening 20 adjacent to the right end of the pressure recovery cylinder 10. This provides a very simple arrangement for recovering the pressure of the steam as it passes through the steam separator.

When the steam separator is in operation in the horizontal position shown in Fig. 1, the water extraction pipes 8 and 21 will remove water from the storage tanks shown as the receiving tank and the lowest portion of the peripheral opening 20. The water is then pumped from these collection areas 7 and 20 by the vacuum pump 9 into a water tank to be reused.

To prevent the seepage of water through the transfer

tube 6, an annular collar or flange 25 is secured on the outer surface of the end of the transfer tube 6 extending into the drying cylinder 1. As the super-saturated steam comes through the inlet pipe 2, a small percentage of the water is thrown to the left from the steam to form a pool 26 which attempts to travel against the annular plate 11 and to follow the smaller diameter transfer tube 6 to flow over the lip and into the pressure recovery cylinder 10. With no transfer tube between the cylinders 1 and 10, a considerable amount of water would be thrown against the annular end plate 11 and would be re-entrained in the low pressure air passing through the apex of the free vortex in the region of this opening. The addition of the transfer tube 6 prevents this creepage.

The addition of the annular collar 25 at the end of the transfer tube 6 causes the water to be thrown from the transfer tube 6 by the spiraling steam admitted by the pipe 2. The location of this collar 25 is critical. If the collar 25 were positioned on the end of a shorter transfer tube, to be in the center of the inlet pipe 2, the whirling turbulence of this part of the inlet stream would accumulate water to such an extent that it would flow over the collar 25 into the outlet stream of the low pressure steam at the apex of the free vortex. If the collar 25 were to be secured to a longer transfer tube 6 too far from the annular end plate 11, the transfer tube and collar would extend into the region of the free vortex and might destroy the vortex and thus disrupt the operation of the steam separator. Regardless of any effect on the free vortex itself this latter construction would extend into the area where the steam is spiralling, so that the steam is flat against the inside wall of the drying cylinder 1 leaving a relative calm which cannot exert sufficient rotating forces on the water on the collar 25 to throw this water centrifugally to the walls of the drying cylinder 1. I prefer that this collar 25 be located on the end of the transfer tube 6 at a point approximately three-quarters of the width of the inlet pipe 2 from the annular end plate 11.

The receiving tank 7 at the right end of the drying cylinder 1 must be positioned so that no water is maintained coaxially aligned with the free vortex. If water were stored in this position, the vacuum at the center of the free vortex would cause a large percentage of the separated water in the tank to flash into steam. This low pressure steam would contaminate the already-dried steam and thereby reduce the efficiency of the separator. Therefore, regardless of the position of the separator, whether vertical, slanted or horizontal, the receiving tank 7 should be constructed so that it does not accumulate water at the continuation of the centerline of the free vortex. Because of the low pressure of the inner spiral of the free vortex, the water must be pumped from the collection areas 7 and 20 into the water tank. Check valves should be placed in the pipes 8 and 21 to prevent a direct connection between the collection areas 7 and 20. These check valves can be of any well known type.

Because of the irregular rate of flow through the inlet pipe 2, it is impossible to prevent some drops of water falling through the apex of the free vortex in the drying cylinder 1. The vacuum at this apex causes many of the drops to be flashed into steam, so that some of the steam is wet thereby. This wet steam mixes with the dry and saturated steam flowing through the transfer tube 6. The wet steam emerging from the transfer tube 6 with a rapid rotation maintains most of its vacuum until it reaches the end plate 17 of the pressure recovery cylinder 10. Any water drops at the center of the free vortex will be thrown out by the centrifugal forces because of the rapid rotation of the vortex against the inner wall of the pressure recovery cylinder 10. Since the water drops are now cooler and moving in the direction of the higher pressure and temperature, they cannot flash into steam and will not be picked up by the superheated steam spiralling along the inner wall of the recovery cylinder 10.

Because of this pressure recovery portion of the steam separator, the steam which escapes through the outlet pipe 16 is superheated. Since the outlet pipe 16 is arranged tangentially, the discharge steam is not rotating, with the rotation being utilized to expedite the tangential discharge.

In order to be efficient, the steam separator drying cylinder which establishes the free vortex must be built rather long with the length a multiple of the diameter. Any attempt to mount this vortex separator vertically on a vehicle such as a locomotive will severely limit the aisle space and space available for other equipment. However, my separator can be mounted horizontally, still providing an economy and still saving water by being far more efficient than other steam separators. The coaxial alignment of the cylinders is not essential as shown by the Letters Patent 2,424,122 issued July 15, 1947 to myself and assigned to the assignee of the present application.

While I have illustrated and described particular embodiments of my invention, modifications thereof will occur to those skilled in the art. I desire it to be understood, therefore, that my invention is not limited to the particular arrangement disclosed, and I intend by the appended claims to cover all such modifications which do not depart from the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

A free vortex steam separator comprising a drying cylinder having a length that is a multiple of the diameter and having one end closed and the other end restricted by an annular plate secured to said cylinder, said multiple being 3 to 50, a pressure recovery cylinder having a diameter substantially the same as that of the drying cylinder having a length that is a multiple of its diameter, said multiple of said drying cylinder being 2 to 5, said pressure recovery cylinder having one end closed and the other end restricted by an annular plate secured thereto, an unrestricted cylindrical transfer tube connecting the orifices of said annular plates and having a diameter approximately half the diameter of said drying cylinder, said transfer tube having relatively short extension into each of said cylinders along the axis thereof, an inlet pipe connected at the end of said drying cylinder adjacent to said transfer tube for admitting supersaturated steam into said drying cylinder tangentially, said inlet pipe being of a width axially of said drying cylinder equal to one and one-third times the length of said extension in said drying cylinder, an annular collar secured to the end of said extension of said transfer tube in said drying cylinder to prevent creepage of water into the transfer tube, said collar extending into the stream of steam flow admitted by said inlet pipe, a receiving tank secured to said closed end of said drying cylinder to store the separated water remote from the axis of the free vortex, an exhaust tube tangentially secured to the end of said pressure recovery cylinder adjacent said transfer tube, and means connected to said receiving tank and said pressure recovery cylinder for removing water separated from the steam.

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