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THERMO-SYNCHRONOUS STEAM TRAP

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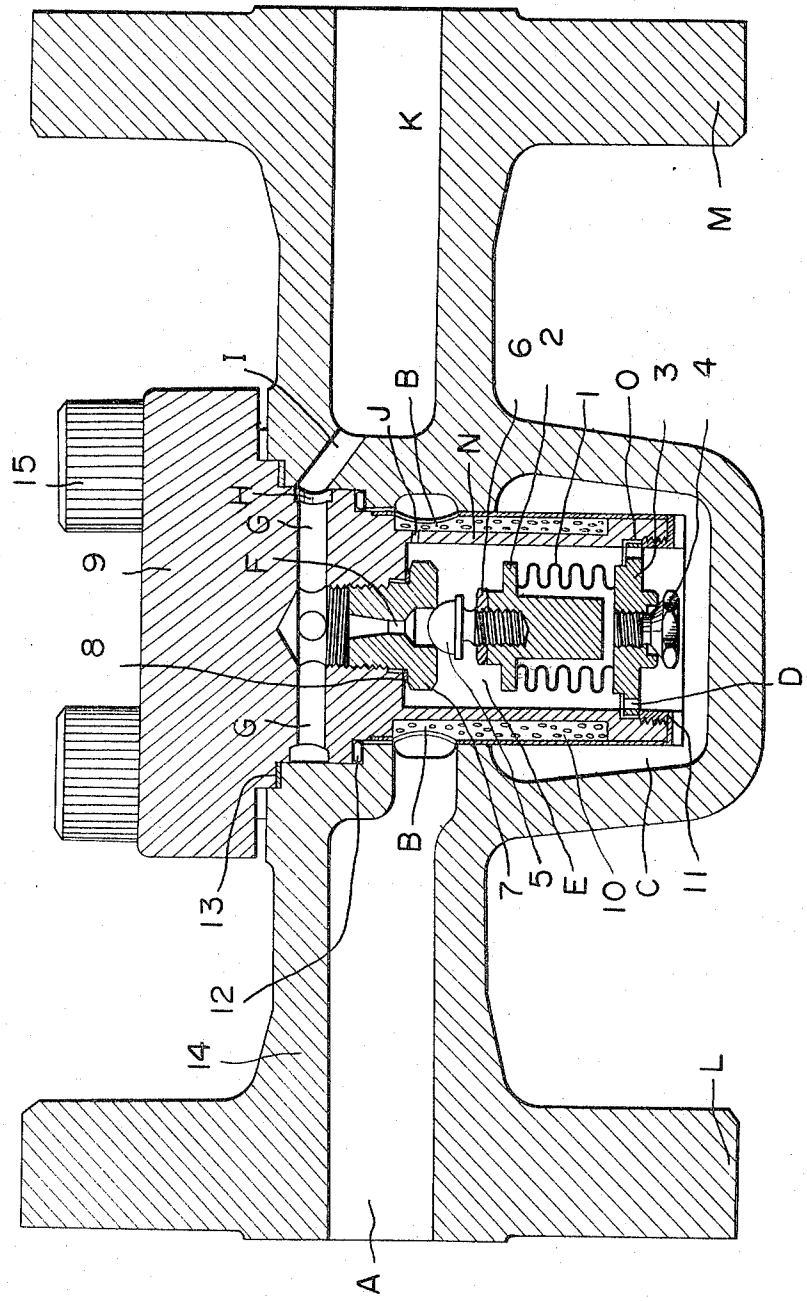

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THERMO-SYNCHRONOUS STEAM TRAP

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This invention relates in general to vapor trap construction, and in particular to a new and useful steam trap having a pressure or actuating chamber for a control fluid for opening and closing the discharge of the trap, wherein the pressure chamber is charged with a fluid of substantially the same characteristics as the fluid being handled by the trap.

With conventional steam traps of a type which include pressure chambers for containing a fluid for actuating a movable member such as a bellows, diaphragm or piston, it is usual to employ an evaporative liquid such as alcohol, ether or the like which is sealed within the pressure chamber. Such a liquid forms a thermo-sensitive control medium for moving the actuation member to open and close the trap in accordance with the evaporation and condensation of such medium. Such evaporation is caused by the temperature variations of the vapor and condensate of the fluid being directed through the trap around the pressure chamber. Traps of this type utilize the movement of the control member by evaporation and condensation of the control medium to open and close the trap discharge.

Traps of the conventional character have the following disadvantages:

(1) Since the evaporation pressure of the liquid within the pressure chamber is considerably higher than the vapor pressure outside of this chamber, the degree of drop of its saturation temperature is very large when it drops to a pressure lower than that of the vapor pressure surrounding the chamber. To achieve this, it is necessary that the temperature of the condensate surrounding the chamber must drop to a considerably low temperature. Thus, traps of this character are not too sensitive. For instance, when alcohol is employed in the bellows, the saturation temperature for 3 atmospheres (gauge) is about 240° F. At this moment, the saturation temperature of the water vapor outside the bellows is around 290° F. for 3 atmospheres (gauge). Therefore, the temperature of the condensate must drop as low as 50° F. (from 290° F. to 240° F.) in order to make the pressure equal within the pressure chamber and surrounding the pressure chamber. A temperature difference of as much as 50° F. will make the trap insensitive and cause the condensate to stagnate for a long time in any machinery and tools which employ steam, and hence adversely affecting the functioning of such machinery.

(2) Liquid having a low boiling point, particularly alcohol, ether and the like, will easily evaporate in open air and when poured into the pressure chamber, will be liable to be scattered and lost. Thus, it is difficult to fill the chambers to the exact fixed quantity and the assembling operation will become more difficult in order to provide the necessary sealing.

(3) When high temperature steam flows into the trap, the movement of the bellows will be limited due to the rise of saturation pressure of the liquid within the bellows, making the use of a trap impossible, so that the range of working pressure is strictly limited and the trap is not effective for use for superheated steam. For instance, water vapor has a saturation pressure of about 15 atmospheres (gauge) for a saturation temperature of 390° F. In the case of alcohol, the saturation pressure is about 27 atmospheres (gauge) for the saturation temperature of 390° F. Therefore, the pressure within the pressure chamber becomes about 12 atmospheres higher.

(4) During the use of the prior art traps, there acts a pressure difference which is normally higher within the pressure chamber than outside, which pressure difference will have adverse effects on the diaphragm or bellows-type of control member and tends to cause a permanent set thereof.

In accordance with the present invention, there is provided a steam trap which includes means defining a pressure chamber for a control fluid with a member movable upon expansion of the fluid within the chamber during evaporation and contraction of the fluid during condensation, and characterized by the fact that the pressure chamber is filled with a fluid which is substantially similar to the fluid which is directed through the trap.

In a preferred arrangement according the the invention, there is provided a steam trap which includes an interior cylinder or tubular member defining a pressure chamber which is closed at one end by a movable piston. The movable piston includes means for opening and closing the discharge of the trap in accordance with the movement of the piston. The pressure chamber is advantageously filled with water. The interior of the trap is advantageously constructed so that the incoming steam will blow downwardly over a shielding umbrella into a condensate chamber or collecting portion below the position of the cylinder. An increase in condensate within the lower portion of the trap causes a cooling of the fluid within the pressure chamber permitting automatic opening of the trap for the discharge of the condensate. When the condensate has been discharged, the higher temperature steam will again cause the control member or piston to move in a direction to close off the discharge of the trap due to the increased temperature of the medium surrounding the pressure chamber.

Further it is found that traps of the conventional character have the following disadvantage.

(5) In a thermostatic steam trap provided with bellows and the like, the end of the bellows opposite the valve side is rigidly fixed to the cover and the like, so that when the bellows expands for closing the valve, the central axis of valve does not coincide with that of valve seat; and consequently, the valve does not close tightly, resulting in some leakage thereof.

(6) In the conventional trap, both of the opening and closing actions, due to contraction of the bellows and the closing action due to expansion thereof, are effected thermostatically, so that there takes place a delay from the time of changing in steam, and of heating of the bellows to the time of opening of the valve due to expansion of the bellows, resulting in leakage of a large quantity of steam. Accordingly, the trap has been bothered by loss of steam and poor thermal efficiency.

(7) In the conventional trap, since the discharge valve is arranged in lower portion thereof, the valve is at all times dipped in the condensate, so that the valve and valve seat are eroded by being dipped and corrosion thereof is caused, by dribble of the condensate. Further, the dribble of condensate in a new article will lower the value thereof as a merchandise.

To eliminate said disadvantages, the folloing proposals will be made according to the present invention and further embodiment thereof is illustrated in FIG. 1, which is a longitudinal section of a bellows type steam trap.

(1) Within a bellows 1, water of room temperature and atmospheric pressure is enclosed in such a way that water is filled under the maximum compression of bellows from its natural length, then the bellows is tightly closed up by a plug 4. In this case, the plug 4 need not be soldered, because the water within the bellows is under room temperature and atmospheric pressure. After the

water is filled within the bellows 1, the bellows is released from its compressed state. It will be expanded a little by its expansive force (elasticity). However, if the atmosphere outside of the bellows 1 is under room temperature and atmospheric pressure, the bellows 1 will not expand sufficiently to restore its natural length.

At this time, the internal pressure of the bellows is lower than the outside pressure by the amount corresponding to the quotient (value) of the expansive force (elasticity) of bellows divided by the cross-sectional area of bellows. For example, let the expansive force of bellows be F lbs. and the cross-sectional area thereof be A in.^{2}, then the pressure difference ΔP between outer and inner sides of bellows will be as follows:

$$\Delta P = \frac{F}{A} \text{ lbs./in.}^2$$

when the bellows 1 is used in a certain atmosphere of steam, the saturated pressure and temperature will be the same because of same quality of water on outer and inner sides of the bellows. The bellows will exist at an equal pressure and expand into its natural length by its own elasticity to contact the valve seat, so that the bellows will be pressed neither from inside nor outside. It will remain under a free state without any unreasonable restriction, except for being subjected to a slight pressure difference at the time of working, which may be given by the following equation:

$$\Delta P = \frac{T + B(P_1 - P_0)}{A}$$

where,

ΔP=pressure difference (lbs./in.^{2}) received from outside when the bellows works
P_1=pressure at inlet port (lbs./in.^{2}, abs.)
P_2=pressure within bellows (lbs./in.^{2}, abs.)
P_0=pressure at outlet port (lbs./in.^{2}, abs.)
A=cross-sectional area of bellows (in.^{2})
B=cross-sectional area of valve hole (in.^{2})
T=elasticity of bellows (lbs.)

(2) A control chamber E is defined between the bellows 1 and a control cylinder N providing a passage for condensate and steam. A discharge valve opening or hole F is provided at the top of chamber E. On the upper part of the cylinder N a discharge hole J is so provided that when the condensate directed into a condensate sump or changer C rises through a passage D into the control chamber E, the steam in this part may be discharged outside of the control cylinder N. Therefore, the condensate may freely flow into the control chamber E and by suitable design of the area of the valve opening F, the volume of control chamber E, and total area of condensate and steam passage D, the valve closing action of bellows are set. This is effected by utilizing the change of dynamic pressure according to the velocity difference due to the differences of density and coefficient of viscosity of condensate and steam flowing in the control chamber E while the valve 5 is opening. The jet of fluid flowing in the control chamber E flows more rapidly when the fluid changes to steam and the change of dynamic pressure becomes larger. So that, when the condensate is discharged and the steam flows in the control chamber E, the jet of steam flow becomes more rapid than the flow of condensate to a low pressure zone, thus the bellows 1 will expand in a moment to close the valve. The pressure outside of the bellows will become lower before the rise of internal pressure due to the heating by steam. Consequently, there is no time-lag or leakage of steam.

(3) Bellows 1, upper lid 2, holder 3, plug 4, valve 5 and lock nut 6 are connected together. The holder 3 for the bellows is arranged by providing sufficient clearance O axially and laterally between the control cylinder and a locking member 11 for the holder. Since the valve 5 is finished as a semi-sphere, even though the bellows may have any distortion due to finishing or may expand in an arc, the valve 5 will be centered on the valve seat 7 without unreasonable restriction.

(4) To eliminate any dribble from the discharge hole, the valve 5 and the valve seat 7 are located at the top of the control chamber E. In addition, at such location the valve is exposed to the condensate only when the latter is discharged. During ordinary operation the valve will be contacted by steam, so that no corrosion is caused and no erosion due to the dribble of condensate will take place on the valve.

(5) Since a screen is provided on the periphery of control cylinder N, the size of the whole body of the trap may be very small, and the weight of the trap is smaller than other similar traps with a strainer. The trap overhaul, assembly and repair become easier, and its maintenance becomes convenient.

In the drawing, 1 denotes a bellows, 2 an upper lid, 3 a holder, 4 a plug, 5 a valve, 6 a lock nut, 7 a valve seat, 8 a gasket, 9 a lid, 10 a screen, 11 a holder locking member, 12 a metallic O ring, 13 a gasket, 14 a main body, 15 a bolt, A an inlet of steam and condensate, B an inlet to screen, C a condensate chamber or sump, D a passage for condensate and steam, E a control chamber, F a valve hole, G a discharge hole bored radially, H an annular discharge passage cut on the periphery of lid 9, I a discharge hole, K an outlet for condensate, L an inlet flange, M an outlet flange, and O clearance.

The steam trap shown in FIG. 1 works as follows: When cold water, air etc. from a steam using device is directed into the inlet A, the valve 5 is apart from the valve seat 7 and the valve port is opened, because the bellows is contracted at first. Cold water and air enter from the inlet B through the screen, where dust and the like are removed. The water collects in the condensate sump C and some air and water pass through the passage D into the control chamber E, and flow through the valve hole F to the outlet K through the discharge hole G, the discharge passage H and the discharge hole I.

In the next place, when steam flows in, the bellows is heated and temperature and pressure of the water within the bellows become raised up to the saturated temperature and pressure of steam on inlet side. In addition the lower pressure zone created by steam flowing in the control chamber E will urge expansion of the bellows so that the valve 5 contacts the valve seat 7 to close the valve. At this moment, the temperature and pressure within the bellows and in the control chamber E becomes equal so that the bellows is in a quite free state. Moreover, such a no-load state of the bellows 1 will continue at all times except the working time, so that the bellows will never be subjected to higher internal pressure such as in the case of a conventional bellows type trap, which would cause any permanent distortion, breaking leakage of internal liquid, and the plug need not be soldered.

And the air tightness of the closed valve is not unreasonably restricted due to free supporting of the bellows unit, thus the valve is seated perfectly for closing. Since the valve portion is exposed to steam, there is caused no corrosion due to dipping in condensate nor dribble of condensate and its durability is very large. Besides, the screen 10 is attached skillfully by utilizing the space effectively, so that the screen 10 may be simply and promptly cleaned merely by detaching the lid 9 and the holder locking member 11. This screen 10 will prevent the valve portion from clogging of dust and marring thereof. Next, the condensate generated in the steam operated device will flow into the condensate sump C to raise its water level gradually through the passage D and into the control chamber E. At this time, the discharge hole J discharges the steam within the control chamber E to the outside of control cylinder N to facilitate the condensate flow into the control chamber E. While the bellows 1 is dipped by

the condensate, then the vapor within the bellows 1 is cooled and condensed to generate a pressure difference ΔP necessary for contracting the bellows and opening the valve 5. This pressure difference ΔP may be calculated by said formula. However, since the water is filled within the bellows 1, the saturated pressure and temperature inside and outside of the bellows become equal, ΔP may be generated by a very small temperature drop of the condensate. This temperature difference may be made very small by appropriate selection of a valve port area and the diameter of the bellows. Thus, high temperature condensate may be discharged, so that the thermal efficiency of steam using machine may be made higher. And, early discharge of the condensate will avoid water hammer and corrosion of the machine and bring about many other advantages.

A slight temperature drop of condensate causes the pressure difference ΔP. The bellows 1 will be contracted due to the boiler pressure which is acting on the surface of the condensate in the condensate sump C and the valve 5 will part from the seat 7. Then the condensate is directed out the valve hole F and is discharged to the outlet K through each passage of G, H, and I. When the condensate is discharged and the steam reaches the control chamber E, the speed of its jet becomes higher than that of the condensate, causing a lower pressure zone, thus the bellows 1 is mechanically and instantaneously expanded without being heated by the steam to raise its temperature and pressure. The valve 5 is moved onto the valve seat 7, completing the valve closing operation.

The working of this trap is based on such an epochal invention that the valve is opened thermostatically and synchronously and is closed thermodynamically. Therefore the valve is gradually opened until the maximum discharge is attained. As the discharge is completed, the valve is closed in a moment.

(1) Since the saturated temperature and pressure inside and outside of the bellows are equal, the pressure difference necessary for operating the device is caused by a slight temperature difference, thus the trap becomes very sensitive.

(2) Since the inside and outside of the bellows are always equal in temperature and pressure, the bellows will never be subjected to any stress due to heat and pressure even at higher temperature and pressure, so that the trap may be used for steam of high temperature and pressure and the bellows, etc., will never cause any permanent distortion.

(3) Since a slight pressure difference ΔP between inside and outside of the bellows occurs only for a few seconds during the operation of the bellows, and at nearly all times the pressure of the outside and inside of the bellows is equal, there is no fear that the tightly sealed water will leak outside, regardless of whether the trap is used or not.

(4) The water of room temperature and atmospheric pressure is enclosed in the bellows, so there is no fear that it will evaporate and disappear. The liquid is obtainable at any place and such troubles as soldering etc., are not necessary.

(5) Since the valve port is attached to the upper side, there will be no dribble of condensate and no erosion of the valve port or corrosion due to dipping of condensate will take place.

(6) Since it is possible to suspend the bellows unit freely and to hold the valve at the center of valve seat by the bellows itself, the air-tightness of the valve portion is excellent and no steam will leak therefrom.

(7) Since the valve may be closed thermodynamically, the closing of valve is quick and sure and no steam leaks therefrom, resulting in no loss of steam.

(8) Since the screen is skillfully provided at a select place, the size is small but the screen has an advantage of large capacity for accumulating dust and the like.

(9) Since the bellows is filled with water and the water

is incompressible, the bellows will never be collapsed even though it is subjected to water hammer and the like.

In this way, according to the present invention such an epochal steam trap may be obtained that has excellent performance, small size and light weight, large amount of drainage, and no limitation in range of working pressure.

While specific embodiments of the invention have been shown and described in detail to illustrate the principles of the invention and the application thereof, it will be understood that the invention may be embodied otherwise without departing from such principles.

I claim:

1. A steam trap comprising a body portion defining an interior condensate chamber, an inlet leading to said condensate chamber, and an outlet passage, means defining a passage leading from said condensate chamber to said outlet passage and terminating in a valve seat located adjacent the top of said condensate chamber, a control cylinder having a closed bottom and defining a control chamber around and below said valve seat communicating with said inlet, said control cylinder having an exterior wall with an annular recess, a screen fitted around the exterior wall of said control cylinder and enclosing the recess, means defining an actuating chamber within said control chamber adjacent the lower end thereof and exposed to the condensate chamber and including a member movable upon changes in pressure within said actuating chamber, said member being disposed in alignment with and below said valve seat and movable upon increase of pressure in said actuating chamber to close said valve seat and upon decrease in pressure within said actuating chamber to open said valve seat, and water sealed within said actuating chamber having the same characteristics as the steam operating fluid for moving said movable member.

2. A trap, according to claim 1, wherein said control chamber includes at least one relatively small sized opening communicating with said inlet.

3. A trap, according to claim 1, wherein said movable member is ball-shaped for seating on said valve seat, said control chamber having a relatively small size opening adjacent the bottom thereof in communication with said inlet.

4. A trap according to claim 1 wherein at least a portion of said discharge passage means is formed as a separate member from said means defining said condensate chamber, said inlet and said outlet passage and comprises a lid defining said outlet passage, a plug in said lid defining said valve seat, said control cylinder being formed as a downward extension of said lid, and a bottom plug closing a portion of said control cylinder and sealing the bottom of said bellows.

5. A trap according to claim 1, wherein said means defining an actuating chamber includes a bellows and a ball-shaped valve carried at the end of said bellows comprising said movable member.

6. A trap according to claim 1, wherein said control cylinder closed bottom and said bellows bottom are defined by a common plug member having a threaded bore, and a plug element threaded into the bore of said bottom plug member and being removable for adding liquid to the bellows.

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