May 19, 1936. E. H. HAMMOND 2,041,544

TEMPERATURE CONTROL APPARATUS

Filed Aug. 4, 1934 2 Sheets-Sheet 1

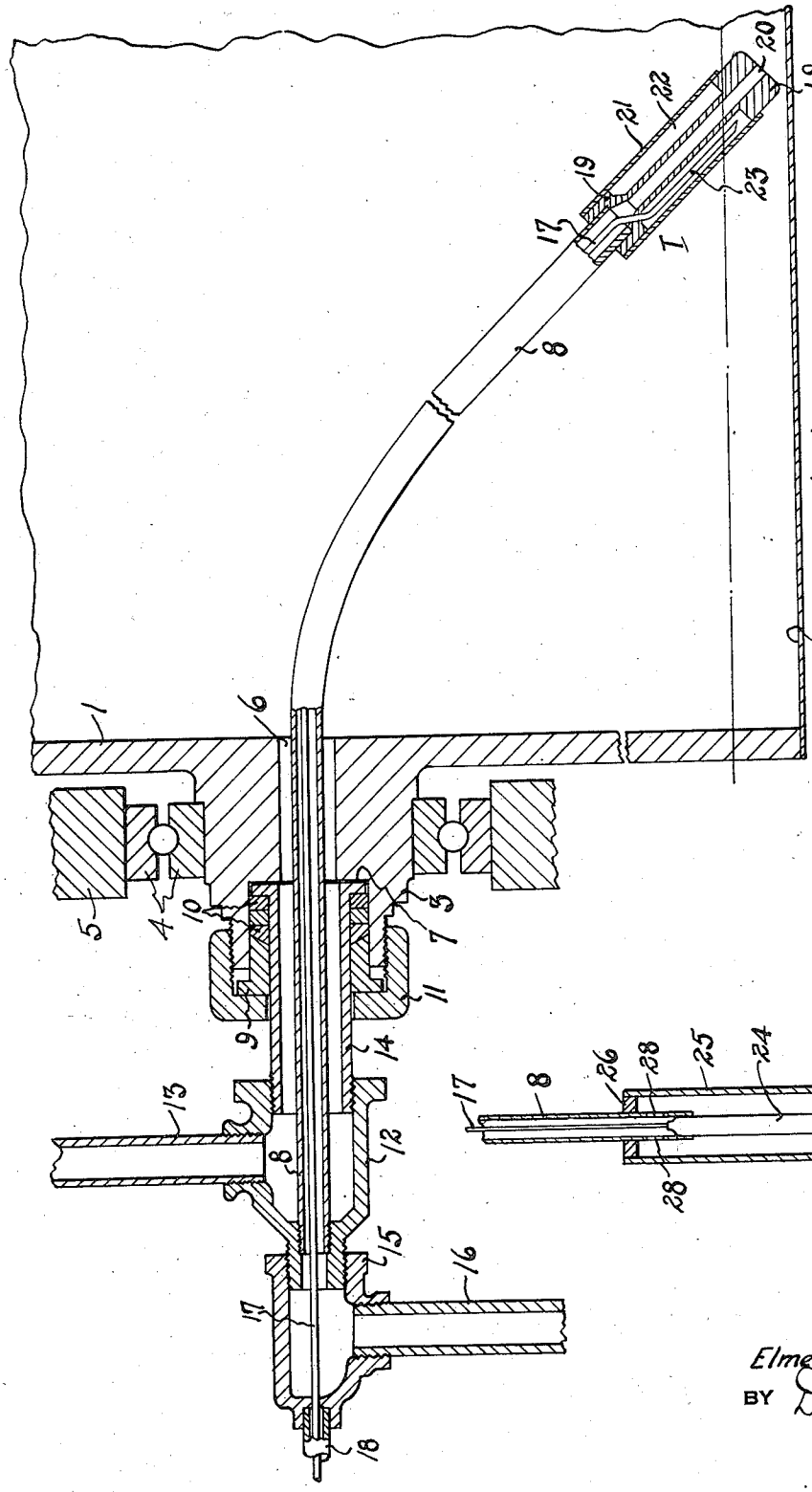



Fig. 1.




Fig. 2.

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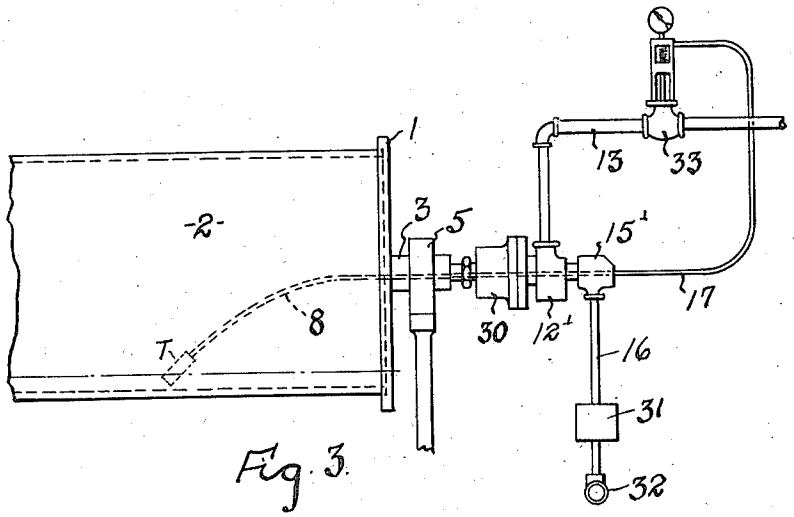



Fig. 3.

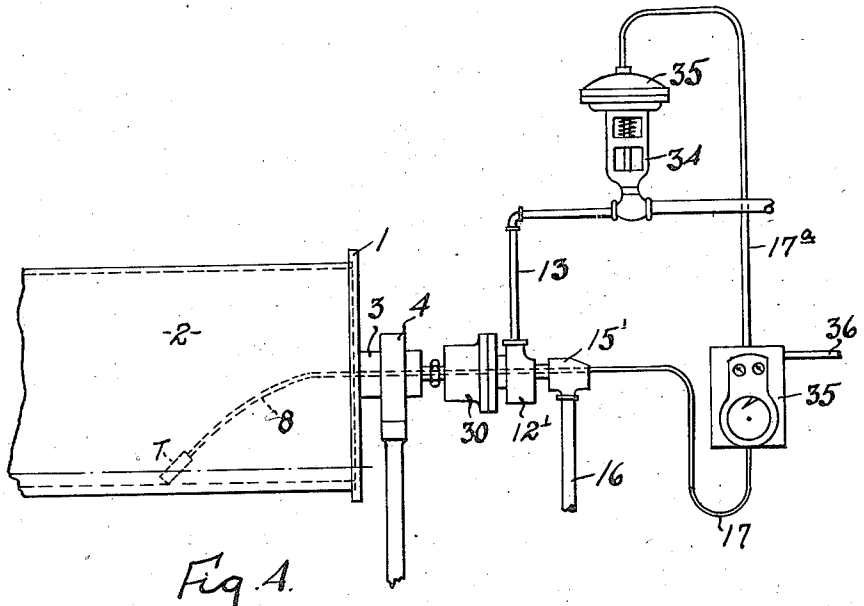



Fig. 4.

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Patented May 19, 1936

2,041,544

# UNITED STATES PATENT OFFICE

2,041,544

## TEMPERATURE CONTROL APPARATUS

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Application August 4, 1934, Serial No. 738,444

15 Claims. (Cl. 236—18)

This invention involves improvements in means for controlling the temperature within a space heated by any fluid which condenses upon cooling, such as steam.

More particularly the invention involves the control of temperature within hollow drums or cylinders which are heated by the condensation of steam within the drum or cylinder under a condition where the condensate is removed therefrom at a rate approximately in proportion to the rate of condensation.

Another object of this invention is to provide a control system of this nature which may be applied to hollow drums which are stationary, or which rotate upon all axes.

A more specific form of the invention is related to the maintenance of temperature in pressure vessels, such as the heating drums of paper drying machines, calendering machines, mill-rolls, cotton slashers, rayon slashers and the like.

For the purpose of disclosing this invention its application to the control of temperature within a rayon slasher of the conventional type, which rotates upon a horizontal axis, will be employed.

The function of a rayon slasher or drying cylinder is to apply heat to the warp subsequent to the passage of the warp through a tank containing a hot sizing solution. The warp leaves the sizing tank and travels over and in contact with a portion of the outer surface of the rotating, cylindrical, slasher roll. It is usual to employ from three to five of these slasher rolls in series and so grouped that the moving warp passes over the heated rolls in succession and in contact with the outer surface of each roll. As the size impregnated warp passes over the heated rolls, the size is fixed or cooked to the warp, thereby increasing the strength and body thereof. This process of sizing the warp is well known and needs no further discussion here.

It is important to produce uniform strength, workability and life in a sized warp to apply the correct amount of heat to the impregnated warp as it passes over the heated slasher rolls. If the temperature of the rolls is too high, the sizing tends to form a hot, scaly coating and to destroy the warp fibres. If the temperature is too low, the sizing will not be properly fixed and the object of the treatment will be defeated. Obviously, if the temperature of the rolls fluctuates, the product will not be uniform. It is highly important therefore, that the temperature of the rolls must be maintained substantially constant and at the proper value.

Since in the form of structure being discussed the roll is rotating, and the steam inlet and condensate outlet are in the center line of rotation, it is rather difficult from a mechanical viewpoint, to locate a thermometer bulb in any way so as to give a true, accurate and reliable indication, record, and/or control of the actual temperature within the roll and of the actual temperature of the roll face. Of course, the introduction of steam directly into the roll for the purpose of heating it, results in the formation of condensate which collects in the bottom of the roll after condensing on the inner surface of the walls thereof. The rotation of the drum of course tends to pick up and maintain a film of water in contact with the inner wall. In an apparatus of this type it is of course the usual practice to remove the condensate from the bottom of the roll as it collects and to remove it preferably at a rate substantially equal to the rate of condensation.

Since the true temperature of the inner wall surface of the roll will correspond very closely to the temperature of the contact surface, betweeen the water films and the wall, and since this temperature will be lower than the temperature of the steam within the roll, it is important to maintain and control as closely as possible the temperature of the water film.

It is not feasible as a practical matter to construct and position a thermometer bulb which will directly indicate the temperature of the water film. The condensate which collects in the bottom of the slasher roll, is, therefore, the next nearest medium in temperature to that of the film temperature with which to work. With a substantially constant formation of fresh condensate and withdrawal thereof from the roll, the temperature of the condensate body remains substantially constant and will bear a substantially constant relation to the temperature of the water film on the inner face of the wall. Since the upper surface of the condensate is in direct contact and approximately thermal equilibrium with the steam, the temperature of this surface will be very nearly the temperature of the steam. From the surface of the condensate to the wall, there will, of course, be a temperature gradient or drop, the amount of which will depend upon the depth and rate of circulation of the condensate.

If the temperature sensitive bulb is placed in the condensate within the heated space of the slasher roll, the bulb will indicate the temperature of the condensate which, in turn, will bear a definite and substantially constant relationship

to the temperature of the water film on the inside of the heated wall. As noted above, the constancy of this relationship will depend upon the conditions of condensate flow, formation, withdrawal and the type, design and location of the bulb. In accordance with this invention the bulb of the thermometer system is partially submerged in the body of condensate which provides an important advantage of this invention, because first, water is a desirable heating medium, and secondly, because of its high specific heat, its temperature does not fluctuate so rapidly. Furthermore in accordance with this invention the bulb of the thermometer system is partially exposed to the steam within the roll. This form of bulb is illustrated in Figure 1. In another form of the invention the thermometer is subjected to the condensate only. This form is shown in Figure 2. While this form of bulb is extremely sensitive and will respond accurately to the condensate of temperature, it has limitations with some types of controller systems, and in connection with some forms of heat exchange apparatus because its extreme sensitivity may cause over control or "surging". Therefore, the form of bulb illustrated in Figure 1 under these conditions is more desirable.

From the above and the following it will be apparent that this invention attains many important objects.

This invention resides substantially in the construction, combination, arrangement and relative location of parts in accordance with the following description taken in connection with the attached drawings.

In the drawings,

Figure 1 is a vertical, central, cross sectional view through a structure embodying this invention with some parts broken away;

Fig. 2 is a central, cross sectional view showing a modified form of thermometer bulb;

Fig. 3 shows a direct temperature control system in accordance with this invention;

Fig. 4 illustrates an indirectly acting temperature control system in accordance with this invention.

There are a number of known systems which seek to maintain constant temperature conditions within a heat exchange apparatus.

In one system the thermometer bulb projects into the chamber so as to be immersed in the steam therein thermodynamically. This method is incorrect since the bulb indicates steam temperature which is not a true indication of the temperature of the roll surface.

In another method the bulb is inserted in a small pressure chamber located outside of the heat exchange apparatus and in communication therewith. Obviously, there will be no constant temperature relationship between the bulb temperature and the temperature within the heat exchange apparatus.

In another method a similar bulb pressure chamber is employed but instead of supplying steam thereto from the heat exchange apparatus, it is supplied directly from the source from which the heat apparatus is supplied. Here again however, there is no definite relationship between the temperature and pressure of the steam in the bulb chamber and in the heat exchange apparatus.

Another method follows the practice of locating the temperature sensitive bulb in the condensate outlet at a point outside of the heat exchange apparatus. However, since the flow of condensate is very small, the heat loss by the conduit before it reaches the bulb assumes considerable proportions. Obviously, therefore, the bulb temperature will be in error because of several uncontrollable factors, such as variation in the rate of condensate flow, heat loss from the conduit, time lag, temperature stratification of the condensate surrounding the bulb and the like.

In another method the thermometer bulb is located outside the slasher roll in the open air so as to be heated by radiation and convection. Obviously, such a system is subject to many errors and inaccuracies which render it of little value.

All of the above methods have been developed because of the mechanical difficulties encountered by reason of the fact that the heat exchange apparatus rotates while in use, necessitating complicated packing joints which are further complicated by the necessity of a connection between the thermometer bulb and the exterior of the apparatus.

An important advantage of the present invention is therefore that in addition to providing a more accurate indication and control of the temperature of the heating, the apparatus by which it is accomplished is considerably simplified.

The structure itself will now be described in detail.

The slasher roll has been indicated as having the end heads 1 (only one being shown) which together with the outer cylindrical metal wall 2, form a closed cylinder. The end heads are provided with trunnions or axles 3 which are journaled by means of ball bearings 4 in suitable fixed supports 5. At least one of these trunnions has a central passage 6 therethrough opening into an enlarged recess 7 in which the flanged end of the coupling tube 14 rests. This tube is held in place by means of a centrally apertured cap screw 11 which bears upon a packing gland 9. Interposed between the packing gland 9 and the flange tube 14 is any suitable packing material 10. The tube 14 screws into a stationary fitting 12 which is supplied with steam or other condensable heating medium through the pipe 13. Extending through the passage 6, tube 14 and fitting 12, is a conduit or pipe 8 which is secured into the wall of the fitting 12. At this point a hollow threaded extension has mounted thereon another fitting 15 to which is connected the condensate waste pipe 16. In turn, fitted into the end of fitting 17, but not opening thereinto, is a protecting tube 18 through which the capillary tube or conduit 17 passes. This tube in turn passes without communication therewith through fitting 17 and conduit 8.

It will be seen from this construction that the roll may rotate on its axis while the parts 8, 14, 12, 13, 15, 16, 17, and 18 remain fixed. These parts are supported in any suitable manner. By this arrangement steam may be introduced from pipe 13 to the interior of the roll and the condensate may be discharged through conduit 8 without intermixture of the two.

The thermometer bulb comprises a fitting 19 having a passage 20 entirely therethrough which fitting is attached to the end of conduit 8 so as to establish communication therebetween. Surrounding the enlarged ends of the fitting 19, is a thin, metal wall 21 hermetically sealed thereto,

to provide an isolated chamber 22 into which the open end 23 of the capillary tube 17 extends. The parts are proportioned so that the lower end of the thermometer bulb T, is submerged in the body of the condensate in the bottom of the roll, the level of which is indicated by a dash dot line. Thus, the thermometer bulb is partially submerged in the condensate so that its passage 20 is below the surface. The remainder of the bulb is exposed to the steam within the roll at the wall 21. The space 22 and the capillary tube 17 are filled with a temperature sensitive fluid. With the exception of the mechanical construction, this type of bulb with particular relationship to its contents, is well known in the arts. Actually such bulb systems may be entirely filled with a liquid, a gas, or a liquid and its vapor in contact.

In the operation of this arrangement, it being assumed that the roll is revolving, steam is fed to the interior of the roll, through pipe 13, fitting 12, tube 14 and passage 6. Under the initial conditions when the apparatus is being prepared for operation, steam will condense rapidly while the apparatus is heating up so that a body of condensate will collect therein.

Due to the difference in pressure between the space within the roll and the tube waste pipe, the condensate will flow up in a small stream through passage 20 and tube 8 into fitting 17. It will be noted of course that the size of this passage will be of the proper size and will actually be quite small. When the apparatus is in approximate equilibrium the rate of condensate formation is approximately equal to the rate of condensate discharge. The temperature sensitive fluid within the space 22 will thus be heated by the flow of heat from the condensate moving through passage 20, and through the wall of fitting 19. The fluid within the space 22 will also be heated by the flow of heat from the steam through the wall 21. Hence the temperature of the fluid within the bulb and the pressure in the closed bulb system will correspond to the mean temperature of the condensate and the steam. If the rate of condensate flow through passage 20 and tube 8 to waste, is at a greater rate than the rate of steam condensation so that the condensate seal at the lower end of the passage 20 is broken, some steam will flow through the bore 20 and tube 8 along with some of the condensate. This will cause an increase in temperature of the fluid in the bulb and by means of control apparatus to be later described, the steam supply valve will move towards closed position to decrease the flow of steam to the cylinder. The condensate seal at the bore will therefore be quickly reestablished. Likewise if the rate of condensation is greater than the rate of condensate removal, the level of the condensate will rise in the cylinder, submerging more and more of the area of the bulb. The resultant decrease in the area of the bulb exposed to steam will cause a temperature and pressure drop in the bulb which through control apparatus will increase the flow of steam to the cylinder forcing more condensate out and reestablishing the proper condensate level and the proper temperature conditions within the cylinder.

From the above description it will be seen that the temperature sensitive bulb fulfills the following important functions,—

1.—It acts as a differential device influenced by the average temperature of which it maintains the steam and condensate,—

2.—It provides a discharge passage for the condensate,—

3.—It tends to maintain a uniform condensate level,—

4.—It acts in an anticipatory manner to correct the fluctuations in the temperature of the steam within the heated space where such fluctuations are not caused by changes in heat demand. For example, assuming the demand for heat is steady, and the initial steam pressure increases, the automatic controller to be described will tend to close the control valve in the steam line thus decreasing the pressure and temperature in the heated space. Likewise, if the steam pressure and temperature dropped below the temperature for which the controller is set, the valve in the steam line will tend to open and increase the steam temperature and pressure. If the bulb were not subjected to the steam, but only to the condensate, any change in temperature of the steam would have to be transmitted to the bulb through the condensate before the bulb would feel this change. Thus, the double wall bulb as described, will be sensitive to changes in the temperature of either steam or the condensate, or both, with a resultant double sensitivity so to speak, providing an even, uniform control.

In some applications of the invention and with some types of controllers, the apparatus and the bulb may function better when exposed to the temperature of the condensate only. In this case an ordinary temperature sensitive bulb 24 is placed within a shield 25 and supported in spaced relation therein by means of a spider 27 and a closure disc 26. The condensate discharge tube 8 is sealed around the upper end of the bulb and is provided with openings 28 which expose the interior of the tube to the space within the shield. With this arrangement, the condensate flows upwardly through the lower end of shield 25, around bulb 24, and into tube 8 through the passage 28. Likewise with this arrangement the temperature of the condensate only affects the bulb. At this point it may be noted that with both forms of the invention the same tube, which supports the bulb, provides the condensate discharge tube. Prior art practice commonly employed separate structures thereby complicating the apparatus and not appreciating the advantages of combining them. In this connection by combining two parts and curving the tube 8 on the lower radius, it is a relatively simple matter in assembling the parts to introduce the condensate tube and bulb through the bearing and steam joint into the roll. Furthermore, by curving the tube in this manner, the bulb is brought in close proximity to the wall of the drum, which, of course, is advantageous.

A simple but complete control system is illustrated in Figure 3 in which the drum and bulb are as before with the drum mounted for rotation on a horizontal axis, the rotary steam joint as shown generally at 30, the steam fitting at 12' and the condensate fitting at 15'. The condensate discharge pipe 16 extends to a trap 31 commonly employed with such arrangements which in turn is connected to the condensate discharge header 32. In the steam supply line 13 is a fluid pressure actuated valve 33 of any one of a number of well known forms. The tube 17 from the bulb extends directly to the actuating mechanism of the valve 33 so that the variations in pressure in the bulb system are applied directly to operate the steam valve 33. Thus, when the temperature in the drum 1 rises, the pressure in

pipe 17 rises, closing valve 33 at the proper point. In the reverse operation when the temperature in the cylinder 1 falls, the pressure in the bulb system drops and valve 33 opens. Throughout the operation the condensate is passing through tube 8 to the condensate header 32 in a manner which is clear from Figure 1.

The system of Figure 4 differs in that the pressure in the bulb system does not directly act upon the motor which actuates the steam valve but acts indirectly through any one of a number of known forms of air or pressure fluid actuated controller. Thus, in this case the tube 17 extends to the controller 35 which not only makes a permanent record of the temperature in the drum but also controls the supply of fluid under pressure, such as air through pipe 36 to pipe 17A. Pipe 17A extends to the diaphragm member 35 which actuates the valve 35 in the steam line 13. Variations in pressure in tube 17 controlled by the device 35 which is known in a number of forms, control the pressure in pipe 17A and hence the diaphragm chamber 35. Thus the device acts as before to maintain a desired temperature condition within the wall.

Of course in both of these systems the apparatus may be set to maintain any temperature between relatively wide limits within the drum.

In general then it will be seen that the device of this invention is based upon improvements by means of which the temperature of the inner wall of the drum to be heated, may be maintained at the desired value. It is of course apparent that if the inner wall is maintained at this value, the outer wall will be at substantially the same temperature. Thermodynamically the system operates so that the steam and condensate within the heated space are in approximate thermal equilibrium, and the bulb is so associated with them as to easily maintain such equilibrium. It may be noted in passing, although it is well known to those skilled in the art, that the tube 17 has a capillary bore and forms with the bulb and any particular device operated thereat, a closed pressure tight system which is filled with a fluid which will either expand or vaporize when the bulb is heated.

From the above description it will be apparent that this invention resides in certain principles of construction and operation which may be embodied in other physical forms without departure from the scope of the invention.

I do not therefore, desire to be strictly limited to the disclosure as given for purpose of illustration, but rather to the scope of the appended claims.

What I seek to secure by United States Letters Patent is:

1. In an apparatus as described the combination comprising a wall to be heated forming a closed space in which condensate collects in contact with the wall, a supply connection for a condensible heating medium for the space, a condensate discharge connection for the space and means in the discharge connection forming a continuation thereof and subject to the condensate temperature within the space for controlling the flow of condensible heating medium through its supply connection.

2. In an apparatus as described the combination comprising a wall to be heated forming a closed space, a supply connection for a condensible heating medium for the space, a condensate discharge conduit for the space, a fluid pressure actuated valve in the supply connection for the condensible heating medium and means in the condensate discharge conduit forming a part thereof and influenced by, and in accordance with, the mean temperature of the condensate of the heating medium within the space and in contact with said wall for actuating the fluid pressure operated valve.

3. In an apparatus as described the combination comprising a heat exchange apparatus forming a closed space, a steam supply connection thereto, the condensate collecting within the space, a condensate discharge connection therefrom and temperature sensitive means within the space and in direct contact with and subject simultaneously to the temperature of the condensate and the steam therein for controlling the supply of steam through the steam connection.

4. In an apparatus as described the combination comprising a heat exchange apparatus forming a closed space, a steam supply connection thereto, a condensate discharge connection therefrom, temperature sensitive means within the space, subject simultaneously to the temperature of the condensate and the steam therein for controlling the supply of steam through the steam connection, said means including a temperature sensitive means in the form of a metallic cartridge having a passage therethrough in communication with the condensate discharge connection.

5. In an apparatus as described the combination comprising a rotatably supported cylinder, means for supplying steam to the interior of the cylinder, the steam condensate collecting in the cylinder, means for discharging condensate from the cylinder including a temperature sensitive device immersed in the steam and the condensate within the cylinder and means connected to the steam supply means and controlled by the temperature sensitive device for controlling the supply of steam to the cylinder.

6. In an apparatus as described, the combination comprising a rotatably supported cylinder, the steam condensate collecting in the cylinder, a steam supply connection, means for connecting the steam supply connection to the cylinder to permit relative rotation, a condensate discharge connection telescoped with the steam supply connection, temperature sensitive means within the cylinder immersed in the steam and its condensate collected in the cylinder and connected to the condensate discharge connection and means connected to the temperature sensitive device for controlling the supply of steam through the steam connection.

7. In an apparatus as described, the combination comprising a rotatably supported cylinder, a steam supply connection, means for connecting the steam supply connection to the cylinder to permit relative rotation, a condensate discharge connection telescoped with the steam supply connection, temperature sensitive means within the cylinder connected to the condensate discharge connection, means connected to the temperature sensitive device for controlling the supply of steam through the steam connection, said temperature sensitive device comprising a closed metallic chamber having a passage therethrough and containing a temperature sensitive fluid.

8. In a system as described the combination comprising a rotatably supported cylinder, a steam supply pipe therefor, means for connecting the pipe to the cylinder so that the cylinder may rotate, a condensate discharge connection, a fluid

pressure actuated valve in the steam supply pipe, a temperature sensitive device within the cylinder forming a continuation of the condensate discharge connection and means for connecting the temperature sensitive device with the fluid pressure actuated valve to control the supply of steam to the cylinder by, and in accordance with, the mean temperature of the condensate and the steam within the cylinder.

9. A device as described comprising a heat exchange apparatus providing a closed space, a steam supply connection to the space, a condensate discharge connection from the space, a fluid pressure actuated valve in the steam supply connection, a thermometer bulb within the space having a passage therethrough in communication with the condensate discharge connection and a capillary tube connecting the thermometer bulb with the fluid pressure operated valve, the lower end of the thermometer bulb being normally submerged in the condensate within the space whereby the bulb is subjected to the temperature of the condensate and the steam within the space.

10. In an apparatus as described, a combination comprising a heat exchange apparatus forming a closed space, a steam supply connection to said apparatus to supply steam into said space, a condensate exhaust conduit from said apparatus telescoped with said steam supply connection, a heat sensitive device immersed in the steam and condensate in said space, means in said steam connection for varying the flow of steam to the space, and a capillary tube telescoped with said conduit and connected between said means and said device.

11. In an apparatus as described, a combination comprising a heat exchange apparatus forming a closed space, a steam supply connection to said apparatus to supply steam into said space, a condensate exhaust conduit from said apparatus telescoped with said steam supply connection, a heat sensitive device immersed in the steam and condensate in said space, means in said steam connection for varying the flow of steam to the space, and a capillary tube telescoped with said conduit and connected between said means and said device, said device having a passage therethrough forming a continuation of said conduit.

12. In a heat exchange apparatus the combination comprising a wall to be heated forming a closed space in which steam condensate collects in contact with the wall, means for supplying steam to the closed space, and means directly subject to both the temperature of the steam and the condensate within the space in close proximity to the wall for controlling the supply of fresh steam to the space.

13. In a system as described the combination comprising a wall to be heated forming a closed space, a steam supply connection to the space, a condensate discharge connection from the space and means close to the wall connected to the condensate discharge connection and forming a continuation thereof and exposed to the condensate within the space for controlling the flow of steam through the steam supply connection.

14. In a system as described the combination comprising a wall to be heated forming a closed space in which condensate collects in contact with the wall, a steam supply connection to the space, a condensate discharge connection from the space and means immersed in both the condensate and the steam within the closed space for controlling the supply of steam through the steam connection.

15. In an apparatus as described the combination comprising a wall to be heated forming a closed space in which condensate collects in contact with the wall, a steam supply connection to the space, a fluid pressure actuated valve in said connection and means in contact with the condensate and steam controlled by and in accordance with the average temperature of the condensate and steam within the space for actuating the fluid pressure operated valve.

ELMER H. HAMMOND.