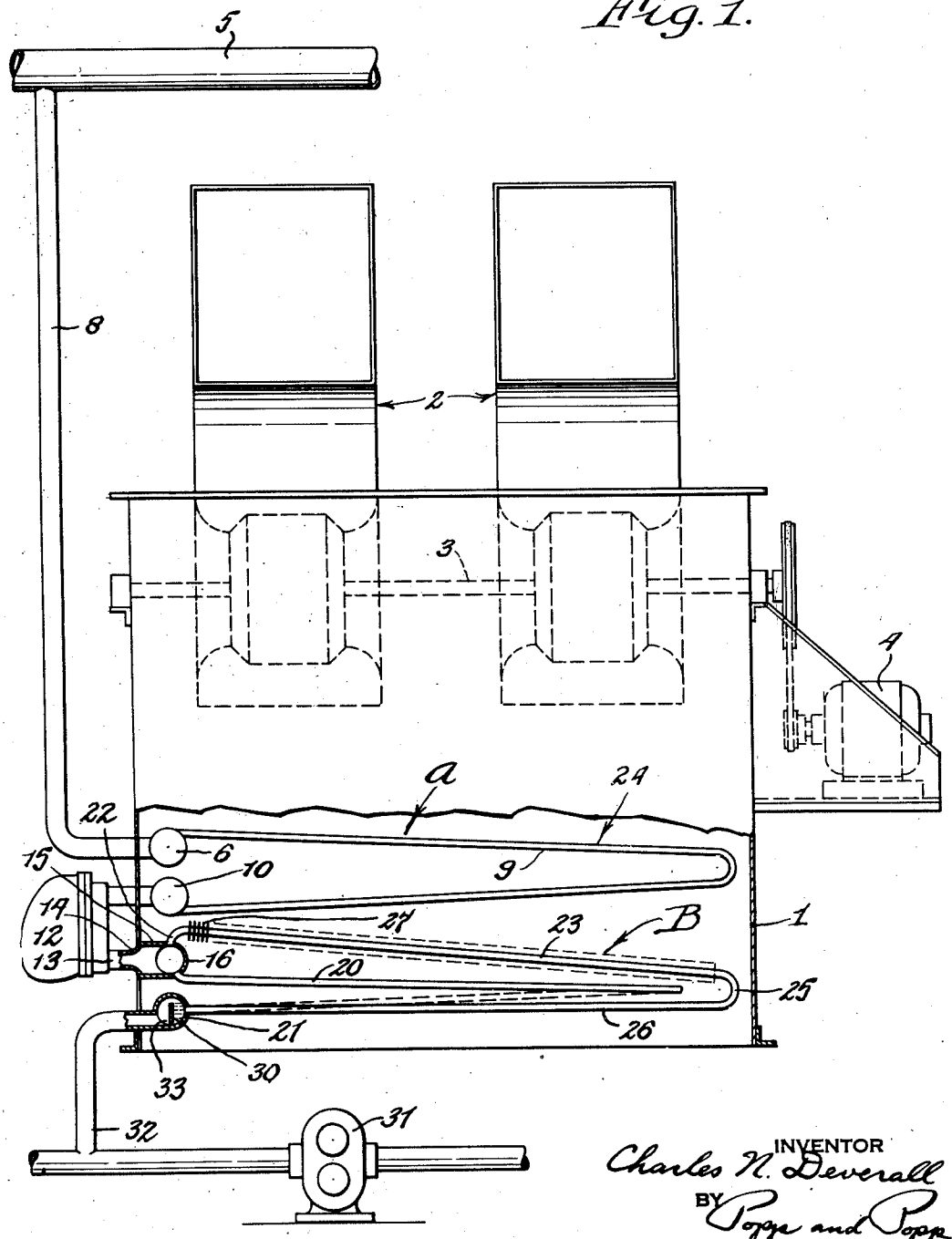
June 25, 1946. C. N. DEVERALL 2,402,610

STEAM HEATING APPARATUS

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Fig. 1.



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Fig. 2.

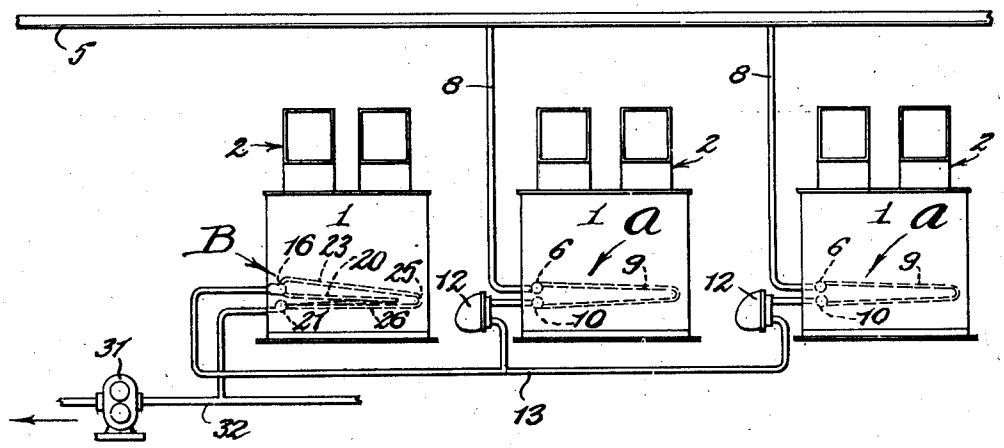


Fig. 3.

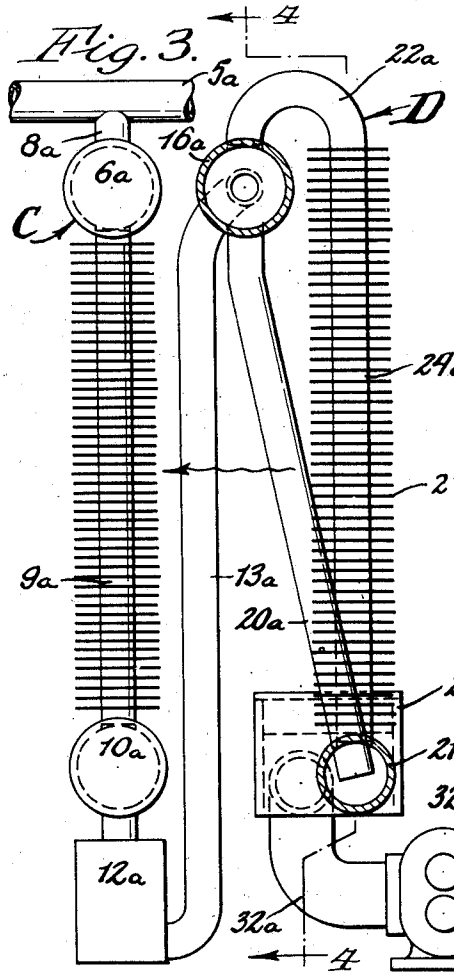
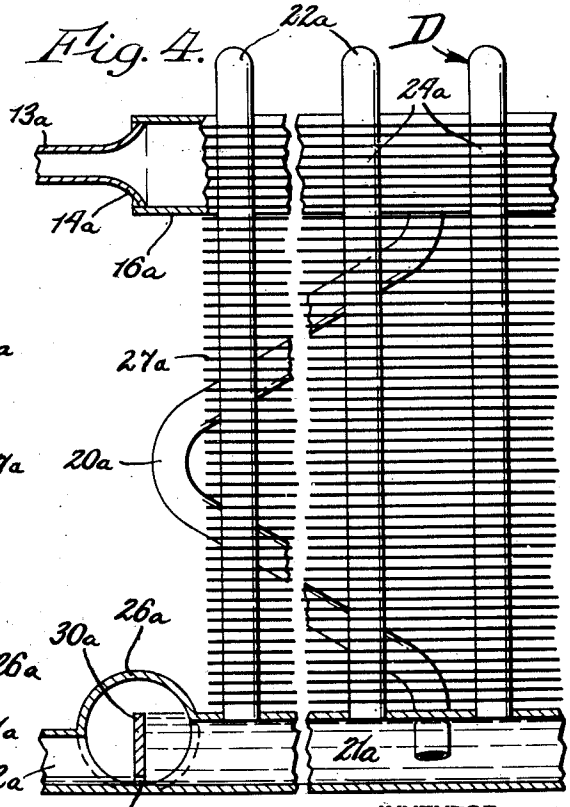


Fig. 4.



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Patented June 25, 1946 2,402,610

UNITED STATES PATENT OFFICE

2,402,610

STEAM HEATING APPARATUS

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Application June 11, 1943, Serial No. 490,405

4 Claims. (Cl. 237—67)

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This invention relates to steam heating apparatus and more particularly to a heating system in which steam is supplied at high pressure and the condensate withdrawn by a vacuum pump and returned thereby to the boiler, the principal purpose of such a vacuum return being to obtain a flow of the condensate over bays, doors and the like which could not be obtained with a gravity return.

As now practiced, high pressure steam systems with vacuum returns are of three general forms, each of which has important disadvantages eliminated by the present invention.

In one form of such high pressure steam heating system with a vacuum return, the high pressure steam is passed through a pressure reducing valve to secondary steam piping, the steam pressure being reduced from, say, 150 pounds in the high pressure steam line to, say, 5 pounds in the secondary piping. From this secondary piping the low pressure steam is passed through the coils of the heaters and the condensate is collected in a trap. The condensate from these traps is withdrawn by a vacuum pump and returned to the boiler. This system suffers from the disadvantage that flashing of the condensate takes place on passing from the traps to the vacuum pump with the result that the vacuum pump is fed with both vapor and condensate and does not function properly. The volume of vapor in the wet steam mixture resulting from this flashing of the condensate is even greater than the original volume of the vapor at the assumed 150 pounds pressure so that the pump, instead of pumping water, attempts to pump water and vapor with the usual result that it does neither, except influx as the return lines fill up. Further, this system suffers from the disadvantage of the vast amount of secondary piping required, together with the pressure reducing valves, bypass arrangements, relief valves, outboard exhaust connections and strainers required. The secondary piping necessarily is larger than the high pressure steam line and the cost of installing and maintaining this secondary piping system represents a very large proportion of the total cost of installing and maintaining such systems as now practiced.

In another form of such high pressure steam heating system with a vacuum return, the condensate from high pressure steam heating coils is fed to a dump trap. As the condensate accumulates therein, the dump trap dumps the condensate into a steam injector. This steam injector is supplied with high pressure steam which forces the condensate back under pressure to the

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boiler and also creates the necessary vacuum in the dump trap to maintain a vacuum in the dump trap and provide the vacuum return. This system, however, suffers from the disadvantage that live steam must be used to return the condensate to the boiler and a large quantity is required.

In a third conventional form of such high pressure steam heating system with a vacuum return, a vacuum pump feeds the condensate from the heating coils to a hot well having a vent. The condensate flashes in the hot well and hence can be handled by a return pump which delivers it to the boiler. This system, of course, suffers from the disadvantage that heat is lost by the flashing of steam and venting it to the atmosphere.

It is accordingly one of the principal objects of the present invention to provide a high pressure steam heating system with a vacuum return in which the condensate supplied to the vacuum return pump is free from vapor and will function properly and at full efficiency at all times.

Another object is to obtain the effective utilization of all of the latent and sensible heat of the steam and to return the condensate to the boiler at a very low temperature.

Another object is to provide such a heating system in which the need for the large size secondary steam piping, pressure reducing valves, by-pass valves, relief valves and strainers is eliminated, thereby effecting a large saving in the initial cost and the upkeep of the heating system.

Another object is to provide such a heating system which does not require the use of live steam to return the condensate to the boiler and to maintain the necessary vacuum in the return.

Another object is to provide such a steam heating system in which the steam and condensate is maintained in a closed circuit so that there is no loss of heat through the flashing of the condensate and venting it to the atmosphere.

Another object is to provide such a heating system which includes a novel form of heating coil for usefully condensing the vapor flashed from the condensate of a high pressure heating coil and which is of simple and inexpensive construction and free from moving parts and insures vapor-free condensate being returned to the vacuum pump.

Another object is to provide such a novel heating coil for usefully condensing the vapor flashed from the condensate in a high pressure heating coil and in which adequate provision is made for the flow of both condensate and vapor and the accumulation of vapor-free condensate for delivery to the vacuum pump.

Another object is to provide such a novel coil which is self-draining on shut-down.

Another object is to provide such a system which is free from hammering or other objectionable noises.

Another object is to provide such a system which will operate at full efficiency without attention and which will stand up under conditions of severe and constant use without getting out of order or requiring repairs.

Another object is to provide such heating apparatus in which a final sub-cooling of the condensate can be effected, that is, in which the condensate is cooled to a temperature lower than the saturation temperature so that there is no danger of its flashing along the line to the vacuum pump.

Another object is to provide such heating apparatus in which sudden surges of large amounts of condensate to the vacuum pump, particularly on starting, are avoided.

In the accompanying drawings:

Fig. 1 is a side elevation, partly in section, of a high pressure steam heating system with a vacuum return and showing my novel form of vapor heating coil for usefully condensing the vapor flashed from the condensate of a preceding high pressure heating coil.

Fig. 2 is a view similar to Fig. 1 and showing a modified form of my invention in which the high pressure steam coils and the novel form of vapor heating coil for usefully condensing the vapor flashed from the condensate of these high pressure steam coils are all arranged in separate casings and in separate air streams.

Fig. 3 is a side elevation of heating coils embodying a modified form of the invention in which the heating coils are designed for a horizontal air flow as compared with the vertical air flow in the form of the invention shown in Figs. 1 and 2.

Fig. 4 is a vertical section, taken on line 4—4, Fig. 3.

In the form of the invention shown in Fig. 1, the coils for heating the air are shown as mounted in the lower part of a rectangular casing 1. This casing is designed for use as a suspended heater and is open at its bottom, the air to be heated being shown as drawn into the casing through its open bottom by a pair of fans indicated generally at 2. The outlets of these fans are shown as extended upwardly through the top of the casing 1 and the fan wheels are shown as mounted on a single fan shaft 3 which is journaled at its ends in the end walls of the casing 1 and driven by an electric motor suitably mounted on the exterior of the casing 1.

In the form of the invention shown in Fig. 1, the high pressure steam of, say, 150 pounds gage pressure, is supplied from a high pressure steam line 5 to a high pressure steam heating coil A in the casing 1 which can be of any type and each of which is shown as comprising a horizontal inlet header 6 connected with the high pressure steam line 5 by a pipe 8 and connected by one or more series of hairpin tubes 9 with a lower outlet header 10. The air to be heated is drawn upwardly through the casing 1 by the fans 2 and around the exterior of the hairpin tubes 9 of each high pressure steam heating coil A, this air cooling the hairpin tubes 9 and condensing the high pressure steam in the coil A. The pressure and the temperature of the steam and condensate, respectively, in the inlet and outlet headers 6 and 10 is substantially the same, the steam

condensing to provide the heat for the air flowing upwardly over the hairpin tubes 9 of the coils.

This condensate, under the same assumed pressure of 150 pounds gage, in the outlet header 10 passes to a trap 12 in which the condensate collects and is withdrawn, under vacuum applied to its outlet line 13. This trap can be of any usual and well known construction and its outlet line 13 flares outwardly, as indicated at 14, and is shown as welded in the relatively large inlet 15 of a header 16, this header forming part of a vapor heating coil B mounted in the casing 1 below the coil A. On entering this inlet header 16, the condensate, being placed under vacuum, flashes, the liquid condensate draining through a drain tube 20 to an outlet header 21.

The vapor resulting from the flashing of the condensate in the inlet header 16 rises and passes through the upwardly extending bends 22 of the overhead legs 23 of a series of hairpin vapor tubes 24, these legs inclining downwardly from the bends 22 to return bends 25, these return bends 25 also connecting with return legs 26 through which the condensate is admitted to the outlet header 21. The upper or vapor leg 23 of each of the hairpin vapor tubes is preferably fin surfaced, as indicated at 27, and is steeply inclined to deliver the condensate collecting therein to the corresponding return leg 26. The return legs 26 have a relatively slight pitch and are substantially filled with condensate so as to act as sub-cooling tubes. For this purpose a weir 30 is shown as welded in the outlet header 21, this weir maintaining a level of condensate in the header and in the return legs 21 and insuring that only condensate is admitted to the vacuum pump 31 which is connected with the outlet 32 of the header 21 and which maintains a vacuum in the heating coil B and also returns the condensate to the boiler (not shown). The pressure maintained in the vapor heating coil B can be 5 pounds or less and by sub-cooling the condensate in the lower legs 26 of the coil B, the condensate can be returned to the boiler at a very low temperature. In order to drain the heating coil B on shutdown a bleed hole 33 is provided in the bottom of the weir 30.

The weir 30 and its bleed hole 33 is not necessary to the operation of the heating apparatus, but provides a means for sub-cooling the condensate and also to prevent, on starting the apparatus, a rush of condensate to the vacuum pump as the condensate must necessarily build up to the height of the weir 30 before passing to the pump in any large quantity. With such a rush of condensate, prevented by the weir 30, the vacuum at the vacuum pump would be substantially lower than the vacuum in the coil B. Hence, if such a rush of condensate were permitted, the condensate might reach the receiver of the pump at a temperature higher than the saturation temperature corresponding to the vacuum in the receiver and flashing would occur. Once the system becomes stabilized, such rushes of condensate do not take place.

In the form of the invention shown in Fig. 2, the construction of casings, fans and coils A and B is the same as that shown in Fig. 1 and hence the same reference characters have been applied. Instead, however, of having the high pressure steam coil A in the same casing as a vapor coil B, it will be noted that the casing 1 at the left hand of Fig. 2 houses the vapor coil B and that this coil is fed with condensate from two high pres-

sure steam coils A each housed in separate casings 1 shown at the center and right of Fig. 2. Each high pressure steam coil A has a trap 12 from which the condensate is drawn to the low pressure vapor coil B, this illustrating that one vapor coil B can be made to serve a battery of high pressure steam coils A and also that the air flow is not required to flow in series first through the vapor coil B and then through the high pressure steam coil A, as illustrated in Fig. 1.

The form of the invention shown in Figs. 3 and 4 operates in the same manner as the form of the invention shown in Fig. 1, the essential difference being that in the form of the invention shown in Figs. 3 and 4 the coils are arranged for a horizontal air flow, whereas in the form of the invention shown in Fig. 1 the coils are arranged for a vertical air flow.

Thus, in the form of the invention shown in Figs. 3 and 4, the high pressure steam is supplied from a high pressure steam line 5*a* to one or more heating coils C which are shown as being adapted for a horizontal air flow, each being shown as having a horizontal upper inlet header 6*a* connected with the high pressure steam line 5*a* by a pipe 8*a* and connected by one or more series of tubes 9*a* with a lower outlet header 10*a*. The air to be heated is shown as having a horizontal flow around the exterior of the tubes 9*a* of the coil C. The pressure and the temperature of the steam and condensate, respectively, in the inlet and outlet headers 6*a* and 10*a* is substantially the same, the steam condensing in the coil C to provide heat for the air flowing over the tubes 9*a*.

This condensate under the pressure of the high pressure steam, in the outlet header 10*a* passes to a trap 12*a* in which the condensate collects and is withdrawn, under vacuum applied to its outlet line. This trap can be of any usual and well known construction and its outlet line 13*a* is shown as extending upwardly and as being flared, as indicated at 14*a*, and is welded into one end of a header 16*a*, this header forming part of a heating coil D. On entering this inlet header 16*a*, the condensate, being placed under vacuum, flashes, the liquid condensate draining through a drain tube 20*a* to an outlet header 21*a*.

The vapor resulting from the flashing of the condensate in the inlet header 16*a* rises and passes through the upwardly extending bends 22*a* of a series of hairpin tubes 24*a*, these tubes extending downwardly from the bends 23*a* to the outlet header 21*a*. The tubes 24*a* are shown as being fin surfaced, as indicated at 27*a*. The lower ends of the tubes 24*a* are sealed in a body of condensate maintained in the outlet header 21*a* and for this purpose one end of this header is formed to provide a transverse chamber 26*a* in which a weir 30*a* is welded. This weir is of such a height as to maintain the header 21*a* full of condensate and insures that only condensate is admitted to the pump 31*a* which is connected with the outlet 32*a* of the chamber 26*a* and which maintains a vacuum in the heating coil D and also returns the condensate to the boiler (not shown). In order to drain the heating coil D on shut-down, a bleed hole 33*a* is provided in the bottom of the weir 30*a*.

It will be seen that the form of the invention shown in Figs. 3 and 4 operates in the same manner as that shown in Fig. 1, the only essential difference being that the coils C and D are designed for a horizontal air flow rather than a vertical air flow. In the form of the invention shown in Figs. 3 and 4 the air is shown as first

flowing through the coil D and then through the coil C, although it will be understood that these coils are not necessarily interrelated in this regard but can be arranged as shown in Fig. 2.

From the foregoing it will be seen that the present invention eliminates the vast amount of large diameter secondary piping, now commonly used in steam heating systems where the condensate is withdrawn under vacuum to permit the return piping to pass over doors, bays and the like, thereby to reduce the installation cost a very substantial extent, particularly as the system forming the subject of the present invention also eliminates the necessity for pressure reducing valves, bypass arrangements, relief valves and strainers.

Further, in accordance with the present invention, the vacuum pump will at all times run at full efficiency and cannot become vapor-bound and at the same time the system provides for the effective utilization of all of the latent and sensible heat of the steam. The system forming the subject of the present invention is also hammerless and otherwise noiseless in its operation.

I claim as my invention:

1. Steam heating apparatus of the character described, comprising a high pressure steam heating coil in a cooling stream and in which the steam is condensed at high pressure, a low pressure vapor coil having an inlet header and an outlet header arranged below said inlet header, a trap between said high pressure coil and said inlet header and blocking the passage of uncondensed steam and receiving the condensate from said high pressure coil and discharging the condensate into said inlet header to flash therein, a plurality of vapor tubes connecting the upper part of said inlet header with said outlet header and exposed to a cooling stream, a condensate tube exposed to a cooling stream and connecting the lower part of said inlet header with said outlet header and conducting the condensate from said inlet header by gravity to said outlet header, the vapors resulting from said flashing passing through said vapor tubes and recondensing therein and the condensate therefrom flowing through said condensate tube and being cooled to a temperature corresponding to the pressure in the discharge of said outlet header, and a pump directly connected with the outlet of said outlet header and returning the condensate therefrom to the boiler and maintaining the low pressure in said low pressure vapor heating coil.

2. Steam heating apparatus of the character described, comprising a high pressure steam heating coil in a cooling stream and in which the steam is condensed at high pressure, a low pressure vapor coil having an inlet header and an outlet header arranged below said inlet header, a trap between said high pressure coil and said inlet header and blocking the passage of uncondensed steam and receiving the condensate from said high pressure coil and discharging the condensate into said inlet header to flash therein, a plurality of vapor tubes exposed to a cooling stream and connecting the upper part of said inlet header with said outlet header, each of said tubes including a bend extending upwardly from said inlet header and a downwardly sloping part connecting said bend with the outlet header, a condensate tube exposed to a cooling stream and connecting the lower part of said inlet header with said outlet header and conducting the condensate from said inlet header by gravity to said

outlet header, the vapors resulting from said flashing passing through said vapor tubes and recondensing therein and the condensate therefrom flowing through said condensate tube and being cooled to a temperature corresponding to the pressure in the discharge of said outlet header, and a pump directly connected with the outlet of said outlet header and returning the condensate therefrom to the boiler and maintaining the low pressure in said low pressure vapor heating coil.

3. Steam heating apparatus of the character described, comprising a high pressure steam heating coil in a cooling stream and in which the steam is condensed at high pressure, a low pressure vapor coil having an inlet header and an outlet header arranged below said inlet header, a trap between said high pressure coil and said inlet header and blocking the passage of uncondensed steam and receiving the condensate from said high pressure coil and discharging the condensate into said inlet header to flash therein, a plurality of vapor tubes connecting the upper part of said inlet header with said outlet header and exposed to a cooling stream, a condensate tube exposed to a cooling stream and connecting the lower part of said inlet header with said outlet header and conducting the condensate from said inlet header by gravity to said outlet header, the vapors resulting from said flashing passing through said vapor tubes and recondensing therein and the condensate therefrom flowing through said condensate tube and being cooled to a temperature corresponding to the pressure in the discharge of said outlet header, a pump directly connected with the outlet of said outlet header and returning the condensate therefrom to the boiler and maintaining the low pressure in said low pressure vapor heating coil, and a

weir arranged in said outlet header and having a drain hole in its bottom part, said weir being arranged to retard sudden surges of condensate from said low pressure coil to said pump.

4. Steam heating apparatus of the character described, comprising a high pressure steam heating coil in a cooling stream and in which the steam is condensed at high pressure, a low pressure vapor coil having an inlet header and an outlet header arranged below said inlet header, a trap between said high pressure coil and said inlet header and blocking the passage of uncondensed steam and receiving the condensate from said high pressure coil and discharging the condensate into said inlet header to flash therein, a plurality of vapor tubes connecting the upper part of said inlet header with said outlet header and exposed to a cooling stream, a condensate tube exposed to a cooling stream and connecting the lower part of said inlet header with said outlet header and conducting the condensate from said inlet header by gravity to said outlet header, the vapors resulting from said flashing passing through said vapor tubes and recondensing therein and the condensate therefrom flowing through said condensate tube and being cooled to a temperature corresponding to the pressure in the discharge of said outlet header, a pump directly connected with the outlet of said outlet header and returning the condensate therefrom to the boiler and maintaining the low pressure in said low pressure vapor heating coil, and a weir arranged in said outlet header and maintaining a head of condensate for a substantial distance along the lower ends of said vapor tubes to provide a vapor seal and to effect sub-cooling of the condensate in said low pressure coil.

CHARLES N. DEVERALL.