Nov. 28, 1939. F. H. WALKER 2,181,750

LONG TUBE VERTICAL EVAPORATOR AND THE LIKE

Filed July 6, 1937 4 Sheets-Sheet 1

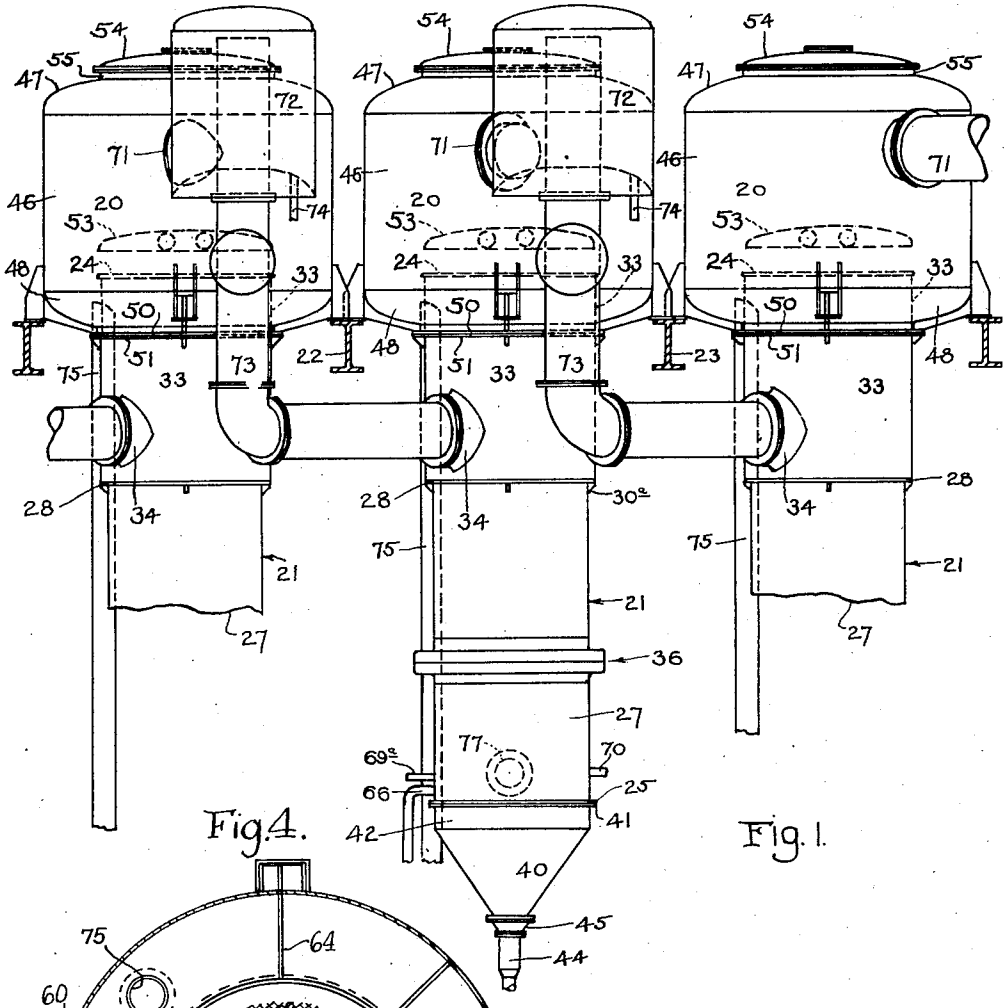


Fig. 1.

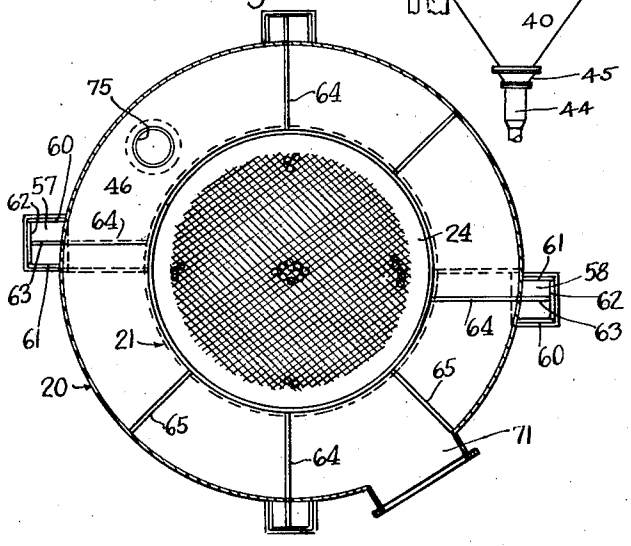


Fig. 4.

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LONG TUBE VERTICAL EVAPORATOR AND THE LIKE

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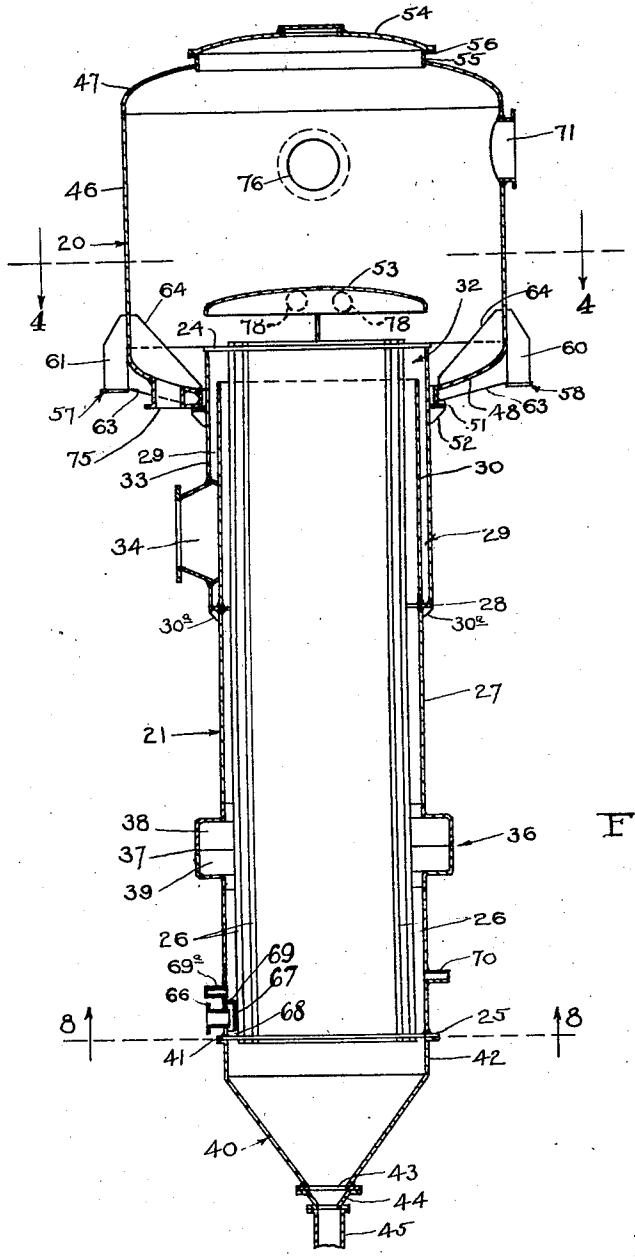


Fig. 2.

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LONG TUBE VERTICAL EVAPORATOR AND THE LIKE

Filed July 6, 1937 4 Sheets-Sheet 3

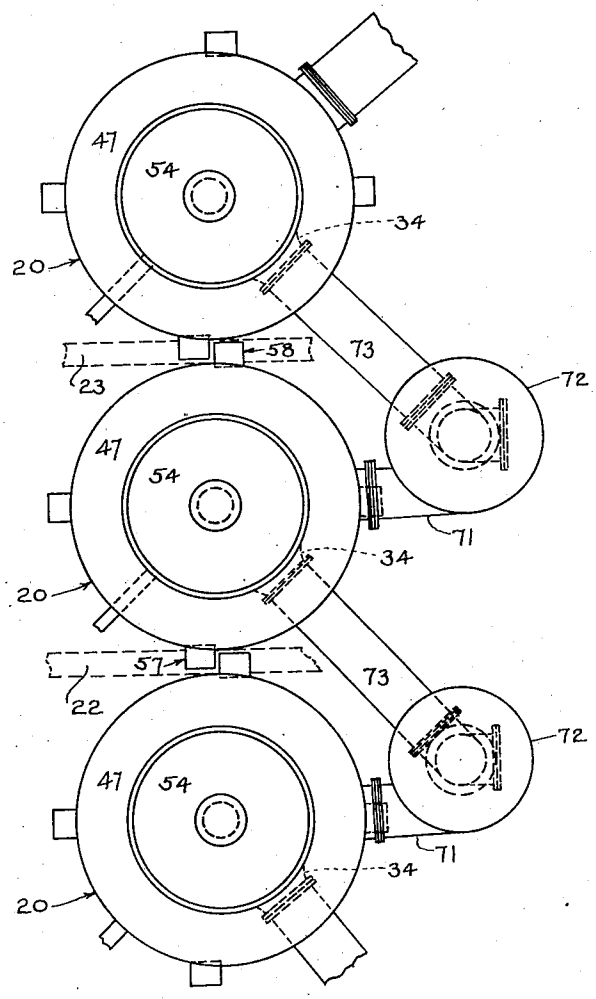


Fig. 3.

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LONG TUBE VERTICAL EVAPORATOR AND THE LIKE

Filed July 6, 1937 4 Sheets-Sheet 4

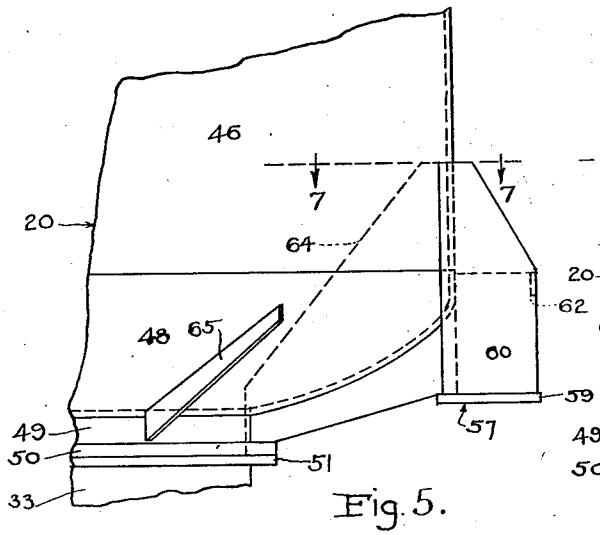


Fig. 5.

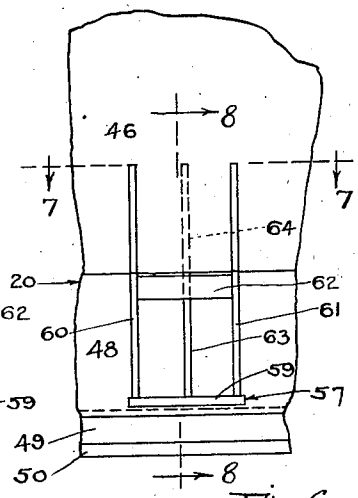


Fig. 6.

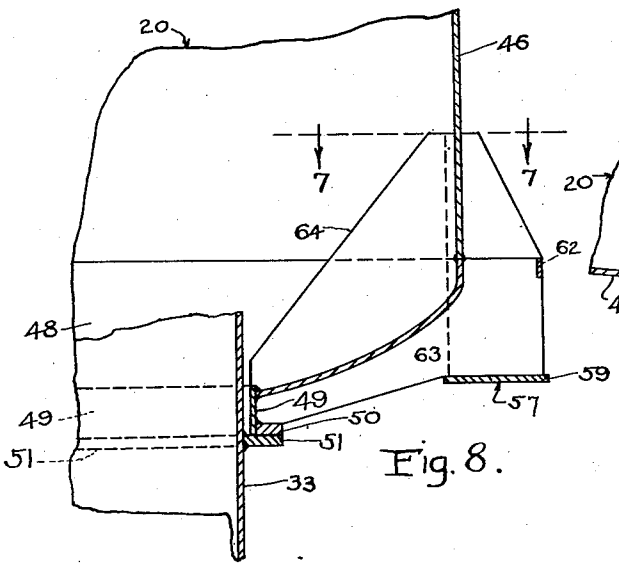


Fig. 8.

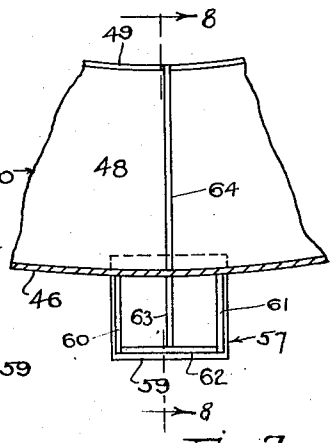


Fig. 7.

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Patented Nov. 28, 1939

2,181,750

UNITED STATES PATENT OFFICE

2,181,750

LONG TUBE VERTICAL EVAPORATOR AND THE LIKE

Floyd H. Walker, Harvey, Ill., assignor to Whiting Corporation, Harvey, Ill., a corporation of Illinois

Application July 6, 1937, Serial No. 152,171

11 Claims. (Cl. 159—27)

This invention relates to certain improvements in evaporators of the long-tube vertical type.

The type of evaporator herein referred to is one which is suspended in a vertical position, the vapor head itself being properly supported and the heating unit and lower portions of the structure depending therefrom. Inasmuch as the heating unit is connected to the lower portion of the vapor head it follows that the entire weight of the heating unit and any liquor contained therein must be suspended. Another object of the invention is to provide a type of construction such that this weight may be properly transferred to the supporting framework of the evaporator without having to transfer said weight thru the lower shell of the vapor head itself. In other words this feature of the invention relates to the provision of a construction in which the heating unit and other depending parts, altho directly connected to the lower shell of the vapor head, are nevertheless themselves directly supported and sustained by the transfer of forces directly to the framework and not thru the lower shell of the vapor head.

In connection with the foregoing it is an object to provide suitable shoes or pads built into or constituting a portion of the vapor head and so arranged that they not only serve to carry the weight of the vapor head itself but also to transfer the load of the heating element and related parts directly to the supporting framework. In this connection it is a further object to so arrange these shoes that suitable reinforcing webs may be built into the lower portion of the vapor head to reinforce the same and at the same time ensure transferring the forces due to the weight of the heating element directly to the supporting shoes.

In connection with the support and installation of these evaporators, it frequently happens that consecutive evaporator units are located side by side and are thus supported by the framework. In those cases in which the vapor heads are brought close together it is nevertheless desirable to be able to carry the supporting shoes of the framework in such a manner that the same frame member will accommodate the shoes from both of the adjacent units. In this connection it is an object of the invention to so arrange the supporting shoes of the different units that they are staggered with respect to each other so that the consecutive evaporators may be brought very close together and be supported by the same frame members.

Other objects and uses of the invention will appear from a detailed description of same which consists of the features of construction and combinations of parts hereinafter described and claimed.

In the drawings:

Figure 1 shows a vertical elevation view of a typical construction of evaporator unit embodying the features of the present invention; the upper portions of the three adjoining units being shown, so as to show the relation of the consecutive units to each other;

Figure 2 shows a vertical longitudinal section through the vapor head, the heating unit and the lower conical inlet section, being on an enlarged scale as compared with Figure 1;

Figure 3 shows the top plan view of the unit with the catchall adjacent thereto; and corresponding to Figure 1;

Figure 4 shows a cross section through the vapor head showing also the top tube sheet, and is a section taken on the line 4—4 of Figure 2 looking in the direction of the arrows;

Figure 5 shows a detailed side-view of one of the supporting feet on enlarged scale showing the attachment of the same to the lower portion of the vapor head and the upper portion of the heating unit;

Figure 6 shows a detailed front-view corresponding to Figure 5;

Figure 7 shows a horizontal section on the line 7—7 of Figure 5, looking in the direction of the arrows, and

Figure 8 shows a vertical section on the line 8—8 of Figure 7 looking in the direction of the arrows.

Referring now to the drawings, the construction illustrated includes the vapor head 20 and the heating unit 21. Generally speaking, the evaporator is supported by a suitable framework, being suspended from above; and in the arrangement illustrated this is effected by means of structural members 22 and 23. The details of this construction will be explained hereinafter:

The heating element itself includes the top and bottom tube sheets, 24 and 25, between which are extended the liquor tubes 26. These tubes are preferably expanded into the upper and lower tube sheets in rigid fashion according to well understood practice. As already suggested herein, it is customary in shop practice to expand the tubes into the tube sheet while the tubes lie in a horizontal direction so that they naturally take a slight amount of bend or deflection during this operation. The amount of this bend is quite small but may amount to as much as one-

half or one and one half inches in a twenty-foot tube length.

Surrounding the lower portion of the tube bundle is an enclosing shell 27, the lower end of which is preferably welded to the outer portion of the lower tube sheet 25. This lower tube sheet however, extends a slight distance beyond the shell 27 so as to establish a flange as shown in several of the figures. The shell section 27 extends up to a position somewhat above the center of the heating element where a ring 28 is welded to it, said ring extending out a sufficient distance to establish a flange which constitutes the lower portion of the annular steam inlet distributive chamber 29. Preferably the ring 28 is reinforced to the shell 27 at various points around the circumference by the webs 30a which are welded in place.

From the position of the ring 28 there extends upwardly the circular baffle cylinder 30, said baffle cylinder 30 terminating at point 31 somewhat below the position of the upper tube sheet 24 so as to establish an annular opening 32 thru which the steam will flow from the annular distributing chamber 29 into contact with the upper portions of all the tubes of the bundle, and the upper tube sheet. It is to be noted that inasmuch as the baffle cylinder 30 does not have to carry any load it can be made of considerably lighter stock than the body portion of the shell 27, thus effecting a considerable saving in cost of material as compared to an arrangement in which this baffle constitutes an upward extension of the shell 27.

There is an upper shell section 33 which extends upwardly from the edge of the ring 28 to the position of the edge of the upper tube sheet 24. This upper shell section 33 is welded at the bottom and top edges to the ring 28 and to the tube sheet 24 so as to establish very strong connections at these points.

At a suitable position the steam inlet connection 34 is welded to the upper shell section 33. The incoming steam from this connection 34 is received into the annular distributing chamber 29 where it is uniformly distributed around the entire unit and then flows upwardly over the upper edge 31 into contact with all of the tubes of the bundle, and the upper tube sheet and from this point the steam flows downwardly around the outside of the tubes and delivers its heat through the tube walls to the upflowing liquor contained within the tubes.

It will be noted that the expansion and contraction of the tubes between the upper and lower tube sheets 24 and 25 will place a strain on the outer shell 27—33 in those cases in which the temperature coefficients of expansion for the tubes and shell are different from each other. In order to relieve the outer shell of strain and to eliminate unnecessary buckling of the tubes I prefer to place an expansion joint 36 in the lower shell section as indicated particularly in Figure 1 herein. The expansion joint 36 is formed by flaring the outer shell outwardly, preferably by a circular section 37 which is welded to the upper and lower portions of the shell, and establishes in effect a corrugation surrounding the shell at the point indicated. The details of construction of the expansion joint 37 are largely optional with the designer, but a simple arrangement is one in which the ring 37 is made of two portions 38 and 39, each of which is of ogee cross section, the two portions 38 and 39 being edge-welded together and each portion thereof being welded to the corresponding shell section 27. It is noted that the ogee sections have the end flanges to the edges of which the welds are made. By this arrangement the bending strains in the ogee sections take place at points considerably removed from the welded joints so that said welded joints themselves are not subjected to bending strains but only to direct endwise pulls or thrusts.

The incoming liquor to be treated is to be delivered into the lower ends of the tubes at the position of the lower tube sheet 25. For this purpose there is provided a lower truncated conical feed section 40 having a flange 41 which is secured to the flange portion of the lower tube sheet 25. This lower conical feed section 40 is formed on an angle of substantially 56 degrees to the horizontal as it has been found in practice that this angle gives the best and most uniform distribution of liquor flowing up thru the conical section into all of the tubes of the lower tube sheet.

The feed section 40 is also provided in its upper portion with a cylindrical section 42 which lies between the cone and the flange 41. This portion 42 is made of sufficient vertical dimension so that when a workmen enters the feed section 40 thru its bottom opening 43 with a tube expanding tool or similar implement he can use the same while working upon the lower ends of the outermost tubes and those which lie close to the cylindrical portion 42 of the conical section. It will be noted in this connection that if the slant of the cone were to be carried directly up to the position of the flange 41 it would be very difficult, if not impossible, to make use of such a tool when working on the outermost rings of the tubes.

The inlet pipe for supply of incoming liquor 45 is connected to the lower end of the feed section 40, either directly, or thru the medium of a short supplemental conical section 44. When the short conical section 44 is used it is connected to the lower end of the feed section 40, and the opening in the feed section 40 is then made large enough so that the workmen can get in and out of the conical section after the portion 44 has been disconnected therefrom.

The vapor head 20 includes a central cylindrical portion 46 together with top and bottom dished and flanged heads 47 and 48, respectively. These portions 46, 47 and 48 are preferably edge welded together with butt-welds to the flanges so as to provide a very smooth and finished construction, and so as to remove the welded joints from the bends at the point of junction of the flanges with the dished portions.

Preferably there is a short flange or ring 49 welded to the opening in the lower dished sheet 48 and extending down a short distance, and a flange ring 50 is then welded to the lower edge of the ring 49. This flange ring 50 in turn is directly connected to the edge portion of the ring 51 which is welded to the cylinder member 33; and if desired a series of reinforcements 52 may be provided for giving additional stiffness to the ring 51 at the point where it is connected to the cylindrical portion 33.

It will be noted that when the heating unit is assembled into the vapor head, the upper portion of the heating unit, that is the portion above the ring 51, reaches up a certain distance into the body of the vapor head. A baffle or deflector 53, preferably of dished form, is located within the vapor head and set some distance above the upper tube sheet 24, being suitably supported at that position. This deflector 53 is preferably concave

downwardly and is separated from the upper tube sheet a sufficient distance to enable liquor flowing up thru the tubes to be caught by such deflector and thrown out sidewise where it will then collect in the lower portion of the vapor head and around the upwardly projecting portion of the heating unit within the vapor head. As a matter of convenience in construction, as well as economy, I prefer to form the baffle **53** from the material or stock which has been cut out of the lower vapor head sheet **48**; and likewise a cover plate **54** for the upper opening in the upper vapor head sheet **47** is preferably made from the stock cut out from said opening during the manufacture thereof. Preferably also a short cylindrical ring **55** is placed around the opening in the upper vapor head sheet **47**, being welded thereto and provided with a flange **56** to which the cover **54** may be secured in the well understood manner.

It will be understood that when installed the heating unit **21** depends from the vapor head in the position shown particularly in Figure 1. The vapor head itself is suitably supported and carried by the beams **22** and **23** already referred to.

The evaporator is supported by the frame members **22** and **23**. These frame members are close to the vapor head which in turn may be provided with suitable shoes or pads which rest upon the frame members. It is to be noted however, that the weight of the heating unit and liquor contained therein is very considerable and if this weight should be directly supported and carried by the bottom sheet of the vapor head the same would be subjected to a very heavy strain requiring the use of very much heavier stock than would otherwise be needed to withstand any internal pressure. I have therefore provided suitable means for supporting the vapor head itself directly on the members **22** and **23** and for also transmitting the load of the heating unit and related parts together with the contained liquor directly to the supporting shoes without having to transfer said load to the lower sheet of the vapor head itself. This construction I will now explain in detail:

At the sides of the unit adjacent to the lower portion of the vapor head are the shoes **57** and **58** which rest directly upon the frame members already referred to. These members are shown in detail in Figures 5, 6, 7 and 8. Each of them includes a bottom shoe or pad **59**, which is adapted to rest directly on the frame member; and extending upwardly from and secured to that shoe are the side webs **60** and **61**. These side webs are preferably welded to the shoe itself and also to the face of the vapor head where they overlie the same.

There is a cross-bar **62** extending between the side plates **60** and **61**; and a third plate or gusset web **63** is located between the side plates **60** and **61**, said gusset web being formed on the same curvature as the lower portion of the vapor head itself and reaching underneath said lower portion to the position of the neck **49** and flange **50**. The edge of this gusset web **63** is welded to the face of the vapor head and the lower sheet thereof and also to the shoe **59**, and this gusset web **63** also reaches to a position beneath the cross beam or bar **62**. It is thus seen that the load of the lower portion of the vapor head and also the load of the heating unit is directly transferred thru the medium of the gusset web **63** to the position of the shoe **59** and then to the frame member, on which said shoe rests.

There may also be provided the internal reinforcing gusset webs **64** on the inside lower corners of the vapor head preferably in line with the gusset webs **63** said webs **64** being welded in place and serving as additional reinforcement of the lower portion of the vapor head at the point where the load of the heating unit is to be transferred sidewise to the position of each shoe. Supplemental gusset webs **65** may also be provided at various spacings around the lower outside face of the vapor head and welded thereto so as to provide additional reinforcement and stiffness thereof.

Referring particularly to Figures 1 and 2, I have therein shown in detail a satisfactory connection for removal of condensate from the lower portion of the heating unit, said condensate representing condensed steam collecting in the lower portion of the heating unit. This condensate connection includes a short tube or nipple **66** extended thru the side sheet of the shell **27** at a point close to the bottom tube sheet **25**; and around the inner inlet end of said nipple **66** there is placed a curved baffle sheet **67**, the same being welded to the inside face of the cylindrical shell **27** and having its lower edge located somewhat above the lower tube sheet **25** so as to provide a condensate opening **68** thru which the condensate may flow to the nipple. The upper end of this baffle **67** is closed by a plate **69** so that a liquid seal is established by the baffle and the plate **69** thus making it necessary for the condensate to flow to the nipple only thru the lower passage **68**. As a consequence, any vapor or entrained gas is prevented from finding its way thru the nipple **66** and a perfect liquid seal is established at the lower end of the heating element. Furthermore by this arrangement the elevation of the condensate in the lower portion of the heating unit is regulated and a uniform discharge thereof is established. By this means the nipple **66** may be located some distance above the lower tube sheet permitting easy bolting of the same to the conical section **42**, but the elevation of liquor on the lower tube sheet will be small due to the fact that the baffle **67** comes down close to the lower tube sheet. If desired, another condensate connection **69***a* may be provided at a higher elevation than the nipple **66**. This connection **69***a* may be normally sealed, but may be used in any emergency occasioned by fouling or closing the passage beneath the baffle **67**, as by accumulation of rust or scale after a long interval of service of the evaporator.

A suitable additional nipple **70** may be connected into the lower portion of the shell **27** at an elevation somewhat greater than that of the nipple **66**, said nipple **70** serving as a means for removing non-condensable gas from the interior of the shell and above the position of any condensate which has collected in the lower portion of the unit. This nipple **70** may be connected to any suitable point for removal thereof so as to keep the interior of the shell effectively vented at all times of such non-condensable gas.

In connection with the foregoing it will be noted that I have provided an arrangement such that the steam is introduced into the upper portion of the heating unit and flows downwardly around the tubes to a position at the lower end thereof where the condensate collects and that the non-condensable gases are also removed from the lower portion of the heating unit. This arrangement insures a very perfect transfer of non-condensable gases downwardly together with the steam and vapors flowing down thru the shell **27** thus insuring a very perfect and complete re-

moval of the non-condensable gases and thereby correspondingly improving the operation of the unit as a whole.

Referring again to the vapor head, as the liquor rises from the upper ends of the tubes **26** and splashes against the baffle or deflector **53**, the vapor is collected in the vapor head and is delivered through the vapor delivery connection **71**. Thence said vapor flows to the "catchall" **72** where any entrained liquor is further recovered. The vapor from the "catchall" is delivered through the vapor flue **73** to another evaporator unit, or to any other suitable delivery point; and the entrained liquor removed in the catchall is delivered through a connection **74** to a suitable point. The main body of liquor separated from the vapor in the vapor head, collects in the lower portion of the vapor head around the upper end portion of the heating unit, and is removed by the connection to a suitable point for disposition. Usually the liquor removed from the catchall through the connection **74** is carried to the same disposition point as the liquor from the connection **75**.

If desired, suitable manholes may be provided in the vapor head, such as at **76**, and in the lower portion of the heating unit shell, such as at **77**, with suitable covers therefor. It is generally convenient and desirable to place a pair of "peepholes" **78** in the vapor head in position to observe the action of the liquor and vapor rising from the tubes **26**, and such peepholes being provided with glasses, and preferably located in alignment with the lower portion of the baffle **53** so that the angle of vision from the eye of an observer looking through a peephole will embrace the space above the baffle as well as the space between the baffle and the upper tube sheet. A lamp may be provided for casting a beam of light through one peephole **78** to shine against the materials within the vapor head so that the action may be better observed by looking through the other peephole.

The downflowing steam in the heating unit causes a substantial "sweeping" action, tending to carry the film of condensate down along the tube surfaces to the lower end of the unit, for collection on the bottom tube sheet and removal through the nipple **66**.

The manhole **77** serves as a convenient means to gain access to the lower portions of the tubes and the lower tube sheet, so that scale and other matter may be easily removed from time to time in order to keep the condensate nipple **66** and baffle **67** open and free for proper outflow of condensate.

While I have herein shown and described only a single embodiment of the features of my present invention, still I do not intend to limit myself thereto except as I may do so in the claims to follow.

I claim:

1. In a device of the class described, the combination of a heating unit including a cylindrical shell, upper and lower tube sheets rigidly connected to the upper and lower end portions of said shell, a series of tubes extending between said tube sheets and having their end portions rigidly connected to the tube sheets, a suitable inlet connection for steam or other heating medium into such shell permitting introduction of said steam or other heating medium into the shell and around the tubes for the purpose of heating the tubes, an outwardly extending flange rigidly connected to said shell at a position beneath its upper end, together with a vapor head in connection with the upper portion of said heating unit, said vapor head being of cylindrical form and provided with dished and flanged upper and lower closures, both of said closures being convex outwardly, said vapor head being of greater diameter than the heating unit, there being a central opening in the lower closure of the vapor head to receive the upper portion of the heating unit, means for connecting the lower portion of the vapor head directly to said flange aforesaid, together with means for supporting all of said parts in vertical and pendant fashion, said means comprising a series of shoes located around the lower portion of the vapor head and rigidly connected to the vapor head for the direct transfer of stresses from the vapor head to structural elements upon which said shoes are resting, together with reinforcing plates extending directly from the position of the connection of the vapor head to the flange aforesaid, to said shoes, for the direct transfer of the weight and load of the heating unit to the shoes, substantially as described.

2. In a device of the class described, the combination of the cylindrical heating unit including upper and lower tube sheets, a series of tubes extending between the said tube sheets, and an enclosing shell extending between the said tube sheets, an outwardly extending flange rigidly connected to said shell at a position beneath its upper end, a vapor head of cylindrical form and greater diameter than the heating unit and having upper and lower dished closures, said closures being convex outwardly, there being an opening in the lower closure for the reception of the upper end portion of the heating unit, a direct connection between the lower closure and the flange aforesaid, shoes located adjacent to the lower portion of the vapor head, supporting connections from the lower portion of the vapor head directly to said shoes, and other supporting connections from the shoes directly to the position of connection of the lower portion of the vapor head to said flange, whereby the load due to the weight of the heating unit and contained material is transmitted directly to the shoes through said connection and irrespective of the lower portion of the vapor head, substantially as described.

3. In a device of the class described, the combination of a vertical heating unit including upper and lower tube sheets, a series of tubes extending between the said tube sheets, a surrounding cylindrical shell enclosing said tubes between the tube sheets, means permitting introduction of steam or other heating medium into said shell and around the tubes for the purpose of heating the tubes, together with a vapor head surrounding and enclosing the upper portion of the heating unit, said vapor head being of generally cylindrical form and provided with dished upper and lower closures, there being an opening in the lower closure for the reception of the upper portion of the heating unit, a series of shoes located adjacent to the lower portion of the vapor head, means directly connecting said shoes to the lower portion of the vapor head, for the purpose of supporting said vapor head, and means supplemental thereto directly connecting the shoes to the extreme lower portion of the vapor head adjacent to the point of connection thereof to the shell of the heating unit for the purpose of transferring the load of said heating unit directly to the shoes irrespective of the vapor head, substantially as described.

4. In a device of the class described, the combination of a cylindrical heating unit including

upper and lower tube sheets, a series of tubes extending between said tube sheets, an enclosing shell surrounding said tubes and extending between the upper and lower tube sheets and connected to said tube sheets, a vapor head surrounding and enclosing the upper portion of the heating unit, said vapor head being of larger size than the heating unit and including upper and lower closures, means for connecting the lower closure of the vapor head directly to the heating unit, a series of supporting shoes around the lower portion of the vapor head, means for connecting such shoes directly to the lower portion of the vapor head, and supplemental means extending from said shoes directly to the point of connection of the vapor head with the heating unit and rigidly connected to said connection, whereby the load of the heating unit together with contained material is transferred directly to said shoes irrespective of the lower closure of the vapor head, substantially as described.

5. In a device of the class described, the combination of a vertical cylindrical heating unit of one diameter having therein means for transferring heat from steam or other heating medium to liquor to be heated, a vapor head of greater diameter surrounding and enclosing the upper portion of the heating unit, means for connecting the lower end of said vapor head directly to the heating unit, load supporting elements adjacent to the lower portion of the vapor head, means for transmitting the load of the vapor head to the load supporting elements and means for transmitting the load of the heating unit to said load supporting elements independently of the vapor head, whereby the load of the heating unit and the contained material is supported independently of the vapor head and at an elevation adjacent to the lower portion of the vapor head, substantially as described.

6. In a device of the class described, the combination of a vertical cylindrical heating unit of one diameter, a vapor head of larger diameter surrounding and enclosing the upper portion of said heating unit, means for directly connecting the lower portion of said vapor head to the heating unit, a series of shoes around the lower portion of the vapor head, gusset webs extending from said shoes directly to the vapor head for direct support thereof, and other gusset webs extending from the shoes past the vapor head directly to the point of connection of the vapor head with the heating unit for direct transfer of the load of said heating unit and the contained liquor therein to the shoes irrespective of the vapor head, substantially as described.

7. In a device of the class described, the combination of a vapor head, a heating unit extending into the lower portion of the vapor head and extending downwardly below the vapor head, means for sealing the vapor head and heating unit together, a common supporting element for both the vapor head and the heating unit and located adjacent to the vapor head, and means to transmit the loads of the vapor head and of the heating unit independently to said supporting element, substantially as described.

8. In a device of the class described, the combination of a vapor head, a heating unit extending into the lower portion of the vapor head and extending downwardly below the vapor head, means for sealing the vapor head and heating unit together, a common supporting element for both the vapor head and the heating unit, means to transmit the load of the vapor head to said supporting element, and independent means connecting the heating unit at a point close to the vapor head, to the supporting element, whereby the vapor head and the heating unit are independently connected to the supporting element, and whereby the portion of the heating unit below the vapor head is suspended from the supporting element and is free to expand and contract, substantially as described.

9. In a device of the class described, the combination of a vapor head, a heating unit beneath the same, means for sealing the heating unit to the lower portion of the vapor head, a common supporting element for both the vapor head and the heating unit, means to transmit the load of the vapor head to said supporting element, and independent means connecting the heating unit at a point close to the vapor head, to the supporting element, whereby the vapor head and the heating unit are independently connected to the supporting element, and whereby the portion of the heating unit below the vapor head is suspended from the supporting element and is free to expand and contract, substantially as described.

10. In a device of the class described, the combination of a vapor head having a bottom closure, a heating unit having its upper portion extending through said bottom closure into communication with the interior of the vapor head, said heating unit extending downwardly a substantial distance below said bottom closure, means to seal the bottom closure and the heating unit together, supporting elements in proximity to the bottom closure, means to transmit the load of the vapor head directly to the supporting elements, and other means to transmit the load of the heating unit to the supporting elements independently of the vapor head and vapor head load transmitting means, substantially as described.

11. In a device of the class described, the combination of a vapor head having a bottom closure, a heating unit having its upper portion extending through said bottom closure into communication with the interior of the vapor head, said heating unit extending downwardly a substantial distance below said bottom closure, a ring sealed to the heating unit adjacent to the bottom closure, means to seal said ring to the bottom closure, supporting elements in proximity to the bottom closure, means to transmit the load of the vapor head directly to the supporting elements, and means to transmit the load of the heating unit from the ring aforesaid directly to the supporting elements independently of the vapor head and vapor head load transmitting means, substantially as described.

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