Aug. 7, 1956 D. T. COUGHLIN 2,757,649

FLUID HEATER WITH GUIDED CONVECTION ELEMENTS

Filed Sept. 9, 1952 2 Sheets-Sheet 1

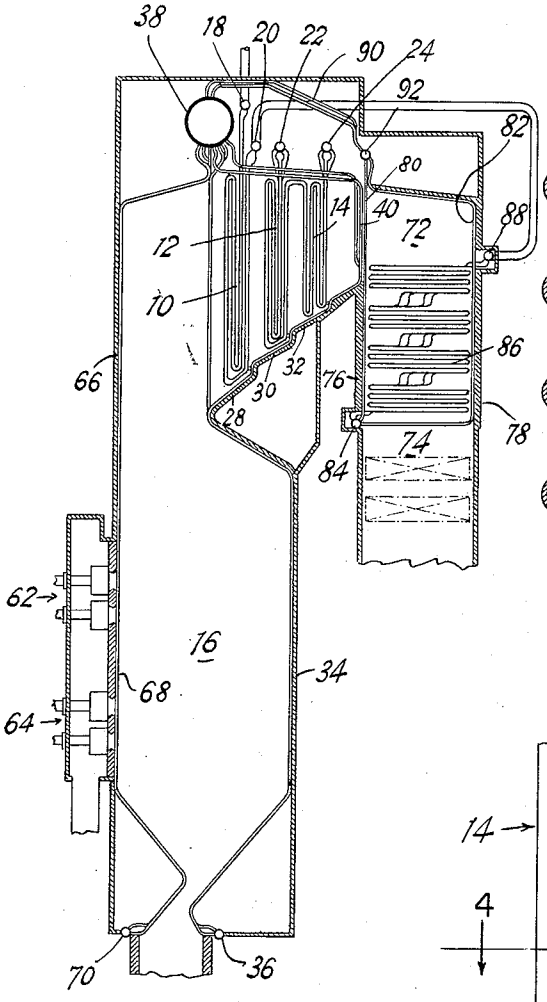


FIG. 1

FIG. 4

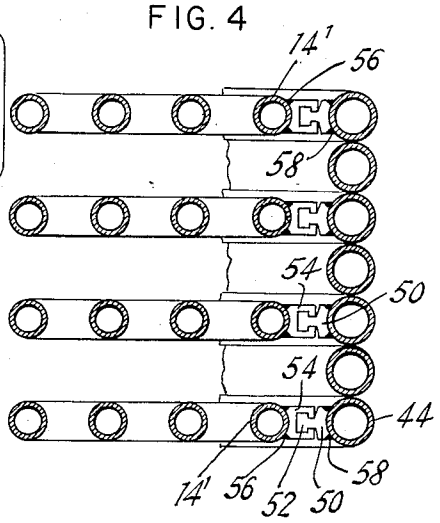
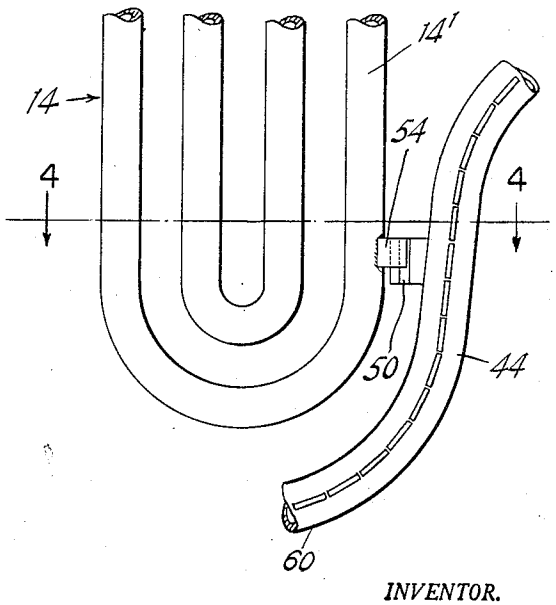


FIG. 3



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FLUID HEATER WITH GUIDED CONVECTION ELEMENTS

Filed Sept. 9, 1952 2 Sheets-Sheet 2

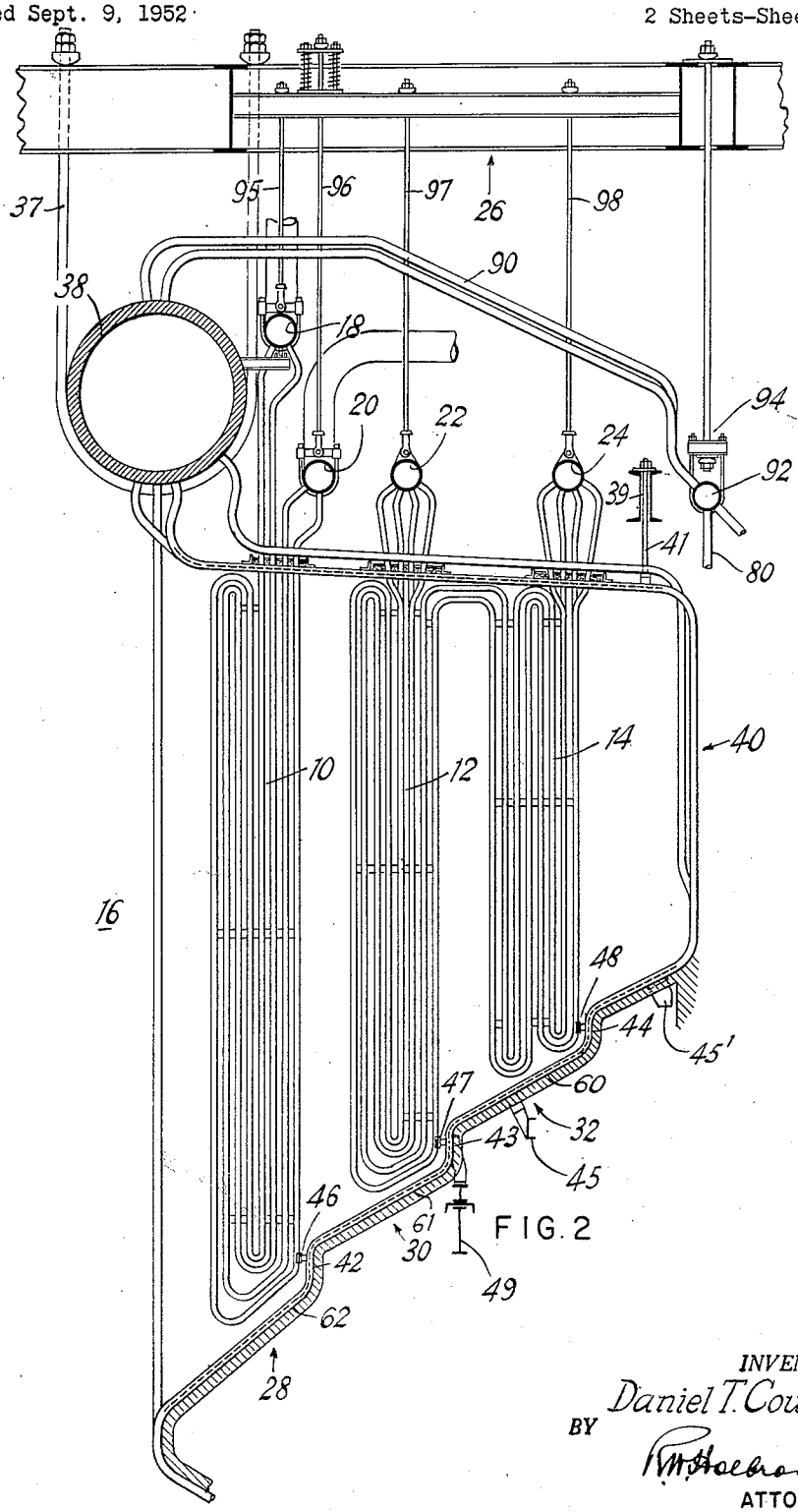

FIG. 2

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FLUID HEATER WITH GUIDED CONVECTION ELEMENTS

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11 Claims. (Cl. 122—478)

This invention relates to improvements in a vapor generating and vapor heating unit employing a pendent type convection vapor heater.

When vapor generating and vapor heating units of the pertinent type are operated at high gas temperatures, it has been found that certain constituents of the gases have corrosive effects upon the pertinent metal, which is greatly increased as metal temperature increases.

Certain sulphur compounds and vanadium compounds resulting from the combustion of oil fuel attack the metals of the vapor generating and vapor heating units, and it is known that the rate of attack of some of these compounds increases with a rise in metal temperature. This is particularly true when the temperature equals or exceeds the approximate melting point of 1290° F. (of the compound). This thermal acceleration of the rate of corrosion attack, at least occurs in the burning of oil fuels which include a vanadium compound and the accelerated attack may be due to a combination of the action of sulphur and vanadium compounds, with the latter acting as a catalyzer.

This corrosive effect has been particularly recognized as of importance in the construction and maintenance of the intersection guides which function to maintain the operative relationship of the components of convection vapor heating means of the pendent type. The sections of such vapor heating means are readily pendently supported from structures which are not affected by the furnace gases, but, in many installations, the lower ends of the vapor heater sections are disposed at positions wholly exposed to the furnace gases and the sections must be free to move downwardly under the influence of the thermal changes to which they are subjected. The lower ends of the sections are guided in their spaced relationship, and if it were attempted to accomplish this result by the use of intersection guides disposed below the sections, and, therefore, in line with the maximum expansion movements of the sections, it would be found that the metal of the guides would have such extensive exposure to the furnace gases that the guides would be subject to excessively high temperatures, and hence subject to substantial destructive effects by the corrosive constituents of the furnace gases.

This invention provides a construction whereby the guides are maintained at such low temperatures (1250° F. or below) that such destructive or corrosive effects are minimized. The pertinent guides also have a minimum of surface exposed to the gases.

The invention involves pendent vapor heater sections disposed transversely of a gas pass with the vapor generating tubes of the floor of the gas pass having parts closely associated with the lower ends of the vapor heater sections. Specifically, these parts involve stepped portions, or steps. Each step of the floor tubes involves an inclined portion and an upright portion disposed in proximity of the downstream side of a vapor heater section. The section is maintained in operative position by an intersection guide having interengaging and slidably related parts, one of which is secured to a vapor generating

floor tube and the other to the adjacent rearmost tube of the adjacent vapor heater section, thus promoting adequate heat transfer from the guide to its attached floor tube by decreasing the ratio of the gas exposed area of the guide to its cross section, and decreasing the ratio of that area to the length of the guide, while permitting the vapor heater section to have adequate upright movements relative to the vapor generating tubes under the influences of different temperature changes. The lower ends of the pertinent vapor heater sections are disposed at a level below the level of the associated guides, the guides being associated with the upright parts of the steps of the pertinent generating tubes.

In the pertinent unit the floor of the vapor heating gas pass is supported from the saturated temperature side wall tubes, and the tubular elements of the vapor heating means, reach a temperature much higher than that of the said wall tubes, which are top hung. Thus, there is relative movement between the lower ends of the vapor heating tube sections and the inclined floor on which the intersection guides are mounted. For example, if we consider a 30 ft. high vapor heating element constructed of an alloy steel known as 18–8 and reaching a metal temperature of 1100° F., as compared to the saturated temperature of 600° F., a differential movement of the order of 2.4″ takes place. At the lower ends of the vapor heating sections, the pertinent arrangement of elements involved in this invention permits such relative movement while disposing the outer or high temperature end of each intersection guide at such proximity to the floor tube to which it is welded that heat is conducted to the tube fast enough to keep the metal temperature of the guide within the desired limits.

The specific combination covered by the invention is set forth in the claims, but for a better understanding of the invention and its characteristics, references should be had to the accompanying description and drawings which disclose a preferred embodiment of the invention.

In the drawings:

Fig. 1 is a sectional side elevation of a vapor generating and vapor heating unit involving the invention;

Fig. 2 is a partial sectional side elevation showing, on an enlarged scale, the illustrative arrangement of the vapor heater sections, the stepped vapor generating tubes, and the associated intersection guides, in sectional side elevation;

Fig. 3 is a detailed view showing the arrangement of the upright parts of a step of a vapor generating tube in its relation to an associated vapor heater platen and the co-acting intersection guide; and

Fig. 4 is a horizontal section on the line 4—4 of Fig. 3.

The vapor generating and vapor heating unit shown in the drawing includes vapor heating means in the form of three banks or groups of upright tubes or tube sections indicated at 10, 12, and 14 as extending across the flow of heating gases from the furnace 16. In the particular unit shown in the drawings, the bank of tubes 10 constitutes a part of a vapor superheater and the banks of tubes 12 and 14 constitute a vapor reheater, but for the purposes of disclosure of this invention, these successive banks of tubes might also be successive parts of the same vapor superheater, or unitary vapor heating means. The pertinent banks of tubes are connected to pendently supported headers 18, 20, 22, and 24. In turn, these headers are pendently supported from the steelwork 26 by pendent supports generally indicated at 95—98. The banks of tubes 10, 12, and 14 of the vapor heater means are disposed transversely of a gas pass having a floor defined by vapor generating tubes having the steps or step formations 28, 30, and 32. Also parts of these vapor generating tubes, as shown in Fig. 1, extend from the lower header 36 along the rear furnace

wall 34, and the upper parts of these tubes continue as a screen 40 across the gas exit of the vapor heating gas pass, then continue along the roof of the gas pass to the vapor and liquid drum 38, which is top supported by hangers such as 37. The roof sections are pendently supported by arrangements of elements such as the fixed beam 39 and the pendent support 41. At the floor of the gas pass the vapor generating tubes are supported from fixed transverse beams such as 45, 45', and 49 fixed at their ends to the side wall vapor generating tubes of the unit (not shown).

While the floor of the superheater gas pass is supported on the top hung side wall vapor generating tubes and moves downwardly to some degree with a temperature increase, the superheater elements expand downwardly to a greater extent when the unit is brought up to operating pressure. This is due to the fact that the superheater elements are heated to a higher temperature and may also be due to the different metallic constituency of the superheater elements.

The shorter vapor heating tubes 14 are associated with the steps 32 of the pertinent vapor generating tubes and the longer reheat vapor heating tubes or tube sections 10 are associated with the steps 28, the vapor heating tube sections (or bank of tubes) 12 of the intermediate length being similarly associated with the steps 30. The steps have upright parts 42—44 (Fig. 2) disposed in proximity to the rearmost tubes of the corresponding vapor heating sections 10, 12, and 14. They are shown in near parallelism therewith so that the sections may be effectively maintained in their operative relationships by the associated intersection guides at 46—48. Each guide (Fig. 4) consists of a metallic T-member 50 with its base welded to the associated upright part 44 of a vapor generating tube, the T-head 52 of the part 50 being freely slidable within a T-slot of the metallic guide member 54 which is welded to a rearmost tube 14' of a vapor heating section.

With this arrangement, each guide is adequately cooled by reason of its close association with a vapor generating tube to which it is secured, and also by reason of its short length and decreased area subject to gas contact.

The lower ends of the sections are disposed at levels below the levels of the associated guides, but they have such clearance relative to the inclined parts 60—62 of the vapor generating tube steps that adequate vertical movements of the vapor heating sections resulting from their thermal expansion are permitted.

The vapor generating unit with which the pertinent vapor heating means is associated further includes groups of burners 62 and 64 disposed along the front wall 66 of the furnace 16. Fuel and air streams are projected into the furnace between the vapor generating wall tubes 68 which extend from the lower header 70 to the steam and water drum 38.

Beyond the gas outlet of the vapor heating gas pass, there is a gas turning chamber 72 at the top of a downflow gas pass 74 having the walls 76 and 78. The upper part of this gas pass has superheater inlet tubes 80 and 82 disposed along its walls and connected to the inlet header 84 of a primary convection superheater 86. The tubes of this superheater lead to an outlet header 88 which is appropriately connected to the inlet header 20 of the secondary superheater formed by the rows of tube sections 10. The superheater inlet tubes 80 and 82 are supplied with steam from the steam space of the drum 38 through the tubes 90 and the interposed header 92. In Fig. 2 the header 92 is shown as pendently supported from the steelwork 26 by hangers 94.

The remainder of the illustrative vapor heating means includes the reheater headers 22 and 24 one of which is appropriately connected to the exhaust of a turbine to supply low pressure and low temperature vapor to be heated in the banks of tubes 12 and 14. The other reheater header is connected to a turbine or turbine stage.

While in accordance with the provisions of the statutes, I have illustrated and described herein the best form and mode of operation of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a vapor generating and vapor heating unit, a convection vapor heater having pendently supported upright tubular sections, wall means forming a gas pass in which the sections are disposed, said wall means including fluid cooled tubes defining a gas pass boundary adjacent corresponding ends of said sections, corresponding ends of the sections being movable relative to said gas pass boundary under temperature changes, the fluid cooled tubes having small parts bent out of the general direction of the tubes and disposed in close proximity to portions of said sections and extending in the general direction of the movement of the sections under temperature changes, and guide means including transversely extending interengaging components connected to said sections and said bent out parts of the boundary tubes for maintaining the convection vapor heater sections in their operative relationship during relative vertical movements of said sections and the fluid cooled tubes, said guide means being disposed directly downstream of the adjacent vapor heater sections in the gas flow path.

2. In fluid heat exchange apparatus, convection vapor heating means including a bank of horizontally spaced upright tubes extending transversely of gas flow, means normally providing for a flow of vapor through said tubes, means pendently supporting said vapor heating tubes, wall means including a bottom forming a gas pass in which said upright vapor heating tubes are disposed, said wall means including vapor generating tubes disposed in alignment along the bottom of the gas pass so as to pass through positions adjacent the lower ends of the vapor heating tubes, the vapor heating tubes being movable relative to the vapor generating tubes at the bottom of the gas pass, the vapor generating tubes having small upright portions bent out of the general direction of the pertinent tubes and disposed in close proximity to lower portions of the rearmost vapor heating tubes and extending in the general direction of movement of said upright parts of the vapor heating tubes, and guide constructions each comprising interengaging and relatively slidably movable parts one of which is secured to a vapor heating tube and the other secured to the adjacent upright part of one of the vapor generating tubes, said interengaging parts being adapted to have relative vertical movements.

3. In a vapor generating and vapor heating unit, a convection vapor heater presenting a bank of spaced upright tubes normally extending transversely of gas flow, means securing said tubes in groups with each group arranged to form a panel or platen, means connecting the upper and lower ends of the adjacent vapor heating tubes of each platen to provide for series flow of vapor through the platen, means pendently supporting the platens, wall means including a bottom forming a gas pass in which the platens are disposed, said wall means including vapor generating tubes arranged in alignment along the bottom of the gas pass, corresponding lower ends of the platens being movable relative to the gas pass bottom under temperature changes, the vapor generating tubes of said bottom having small upright portions closely adjacent upright portions of selected platen tubes and bent out of the general direction of the vapor generating tubes and extending in the general direction of movement of the platen tubes under temperature changes, and giude constructions for a plurality of the platens, each guide construction including interengaging parts one of which is fixed to a rearmost platen tube and the other fixed to the bent

out upright part of one of the vapor generating tubes, the interengaging parts of each guide construction being capable of relative vertical movements.

4. In a vapor generating and superheating unit, a furnace having boundary surfaces defined by rows of vapor generating tubes, wall means including parts of some of said tubes and defining the floor of a convection vapor heating gas pass leading from the furnace, a bank of upright convection vapor heating tubes forming rows of pendently supported platens with their lower end portions disposed in successive steps at different vertical positions, some of said gas pass floor tubes having small portions bent out of the general direction of the pertinent tubes, said bent out portions forming successive steps with the upright tube portions of the steps extending in the general direction of movement of the vapor heating tubes under temperature changes, the vapor heating tubes at corresponding ends of the platens being disposed in proximity to said upright parts of the steps, and intersection guide means including interengaging relatively slidable parts secured respectively to said upright portions and the adjacent upright parts of the platen tubes to maintain their proximity relationship during relative movements of the platens and the floor to the gas pass.

5. In a vapor generating and vapor heating unit, a furnace having vapor generating tubes included in its walls, wall means forming a gas pass leading from the furnace, said wall means including parts of same said vapor generating tubes, some of said vapor generating tubes of the gas pass having multiple bends bent out of the general direction of the tubes and forming successive steps of an inclined wall or floor of the gas pass, a bank of upright convection vapor heating tubes forming rows of pendently supported platens with the lower ends of the platens arranged in sucessive rows and disposed in successive steps of the vapor generating floor tubes, the steps of said floor tubes having upright parts disposed rearwardly of the inclined parts of the floor tubes, the lower ends of the platens of the vapor heating tubes being movable relative to said floor under temperature changes and the steps of said floor tubes extending in the general direction of movement of the platens under temperature changes, the vapor heating tubes at corresponding ends of the platens being disposed in proximity to the upright parts of the steps, and intersection guide means including interengaging relatively slidable parts secured respectively to the upright parts of the steps and the rear most tubes of the platens to maintain the proximity relationship of the upright parts and tubes while permitting the platens to move vertically relative to the floor tubes.

6. In a vapor generating and vapor heating unit, a vapor generating system including a furnace with vapor generating tubes in its walls, wall means forming a vapor heater gas pass leading from the furnace, said wall means including a floor with vapor generating tubes therein having multiple bends of parts bent out of the general direction of the tubes and forming a plurality of successive steps, said steps of the floor tubes including upright parts, sections of pendent vapor heating tubes disposed in the gas pass and across the path of gas flow from said furnace and having the lower parts of successive sections disposed in successive steps of the floor tubes with the rearmost tubes of said successive sections disposed closely adjacent said upright step parts, the upright step parts extending in the general direction of expansion and contraction movements of the lower parts of the vapor heating tubes, and intersection guide means including interengaging and relatively slidable parts secured respectively to the upright parts of the steps and the adjacent parts of the vapor heating tubes, the relatively slidable movements of the parts of the guide means taking place in a vertical sense.

7. In a vapor generating and superheating unit, a convection superheater including a bank of spaced upright tubes extending transversely of gas flow, means pendently supporting said superheater tubes, a floor and wall means forming a gas pass in which the superheater tubes are disposed, said means including vapor generating tubes disposed along the floor of the gas pass and adjacent to the lower ends of the superheater tubes, the lower ends of the superheater tubes being movable relative to the gas pass floor under temperature changes, the vapor generating gas pass floor tubes having small parts bent out of the general direction of the tubes and disposed in close proximity to the rearmost superheater tubes and extending in the general direction of expansion and contraction movements of the superheater tubes, said bent out parts being upright and transversely aligned across the gas pass, and intersection guide constructions each comprising interengaging parts one of which is secured to a rearmost superheater tube and the other secured to one of the upright bent out parts of the gas pass floor tubes, said interengaging parts of the guide constructions being so associated as to have relative upright slidable movements.

8. In a vapor generating and vapor heating unit, a convection vapor heater presenting a bank of spaced upright tubes extending transversely of gas flow, means for securing said tubes in groups with each group arranged to form a flat section or platen, means connecting the upper and lower ends of the adjacent heater tubes of each section to provide for the series flow of vapor therethrough, means pendently supporting the heater sections from a position above a gas pass, vapor generating tubes arranged in alignment along the floor of the gas pass so as to pass through a position adjacent the lower ends of the heater sections, said vapor generating tubes having upright parts disposed closely adjacent the upright lower portions of the rearmost heater tubes of the sections and extending in the general direction of movement of the vapor heating tubes under temperature changes, and intersection guide constructions each comprising interengaging parts one of which is secured to a heater tube and the other secured to the upright part of one of an adjacent vapor generating tube, the interengaging parts of each guide construction being capable of relative vertical movements.

9. In a vapor generating and vapor heating unit, a vapor generating system including furnace wall tubes, wall means including parts of some of said vapor generating tubes defining a convection vapor heater gas pass leading from the furnace, the vapor generating tubes at the bottom of the gas pass having small portions bent out of the general direction of the tubes and forming a plurality of successive rows of aligned steps, said steps including upright parts, successive rows of sections of pendent heater tubes disposed in said gas pass and across the path of gas flow from said furnace and having the lower parts of successive sections disposed in said successive steps with the end tubes of the section disposed closely adjacent to said upright parts, the upright parts of the steps extending in the general direction of the movement of the vapor heating tubes under temperature changes, and intersection guide means including interengaging and relatively vertical slidable parts secured respectively to said upright parts of the steps and the adjacent end tubes of the heater sections, the guide means being disposed downstream of the associated heater sections in a gas flow sense.

10. In a vapor generating and heating unit, a convection vapor heater presenting a gas pass and a bank of spaced upright tubes extending transversely of the flow of a gaseous heat exchange medium, means normally providing for a flow of vapor through said tubes, means pendently supporting said heater tubes, vapor generating tubes arranged in alignment along the floor of the gas pass, said vapor generating tubes having transversely aligned small upright parts bent out of the general direction of the tubes and disposed closely adjacent the rearmost heater tubes, said upright parts extending in the gen-

eral direction of the movement of the vapor heating tubes under temperature changes, and intersection guide constructions each comprising interengaging parts one of which is secured to a rearmost heater tube and the other secured to the upright part of one of the vapor generating floor tubes, said interengaging parts of the guide constructions being so constructed and associated as to have relative upright slidable movements.

11. A convection fluid heater comprising a plurality of heater tube sections each including a seires of connected parallel tube lengths, wall means forming a gas pass in which the sections are disposed, said wall means including fluid cooled tubes defining a gas pass boundary adjacent corresponding ends of the sections, said corresponding ends of the sections being movable relative to said boundary under temperature changes, the fluid cooled tubes having small parts bent out of the general direction of the tubes and disposed in close proximity to the outside tubes of the heater sections and extending in the general direction of movement of the sections under temperature changes, and intersection guide con-

structions each including relatively movable interengaging metallic parts one of which is fixed to an outside heater tube section or length and the other fixed to one of the small bent-out parts of the fluid cooled boundary tubes, said inter-engaging parts of the guide constructions being capable of relative movements in the general direction of expansion of the heater tube sections due to temperature increases.

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