

Jan. 12, 1960

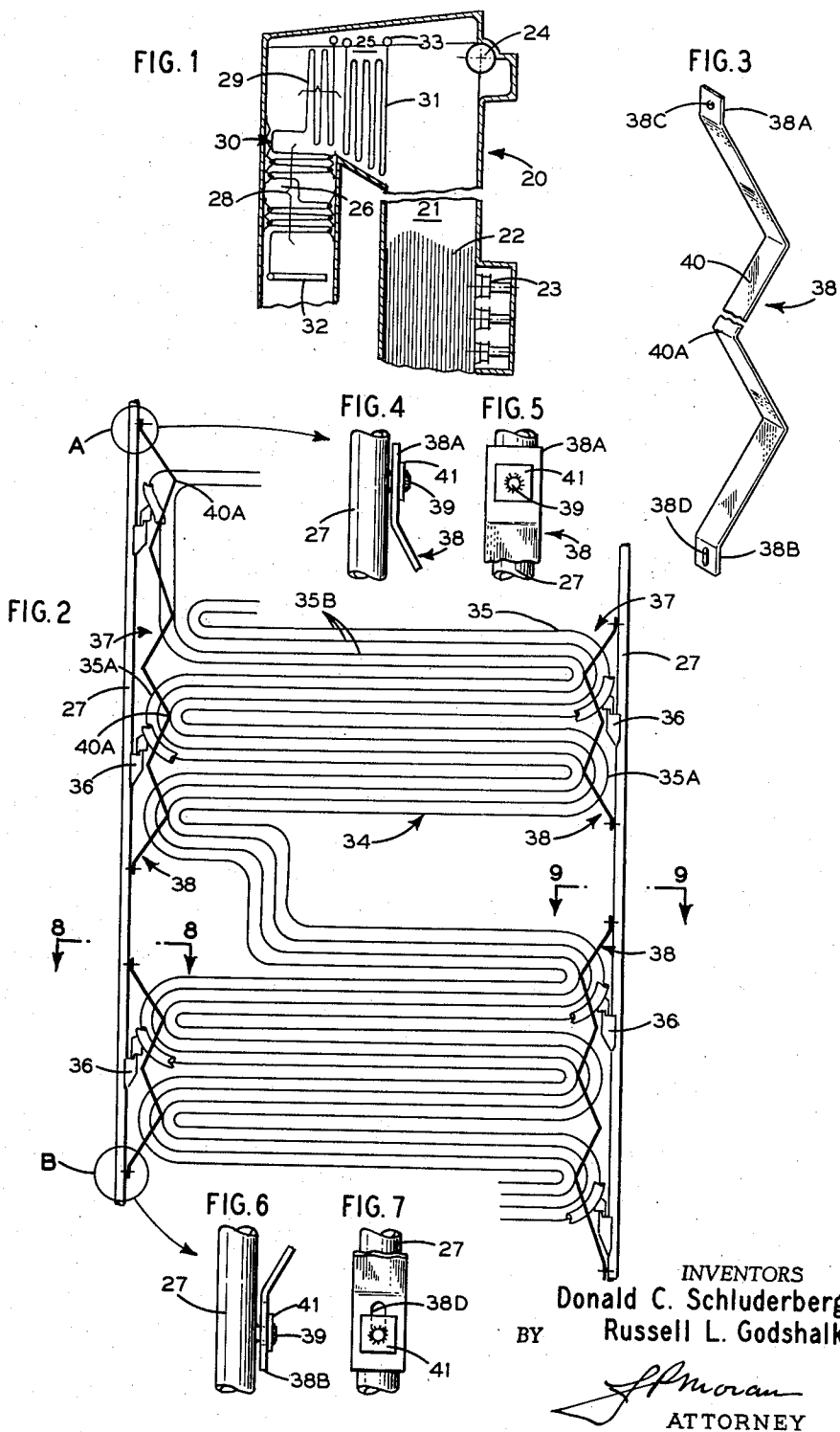
D. C. SCHLUDERBERG ET AL

2,920,873

FLUID HEATING UNITS

Filed Oct. 18, 1957

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FIG. 8

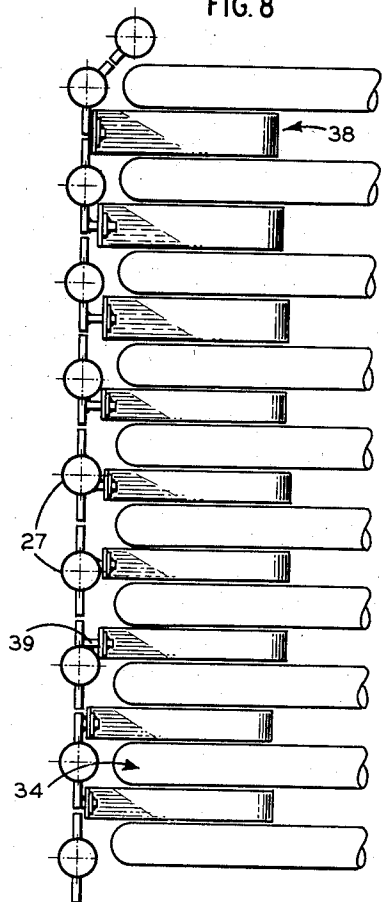


FIG. 9

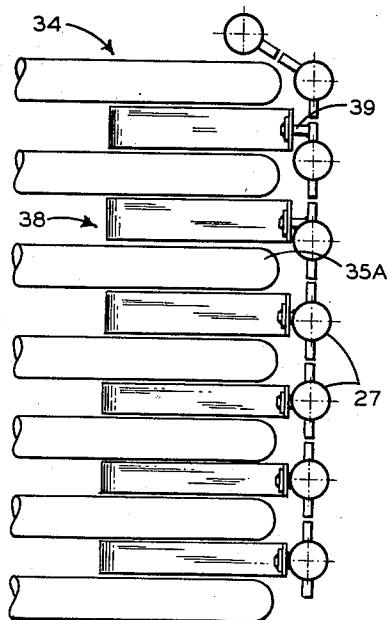


FIG. 14

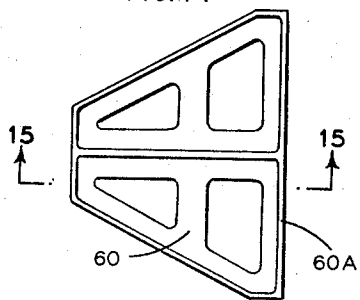


FIG. 15

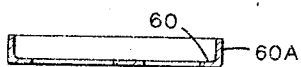


FIG. 12

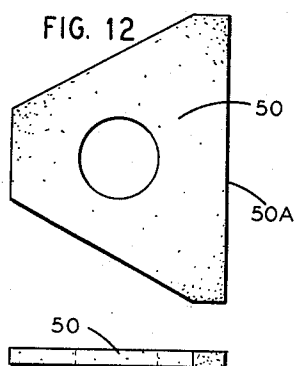


FIG. 13

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FIG. 17

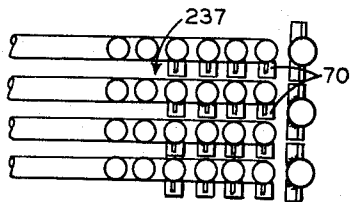


FIG. 11

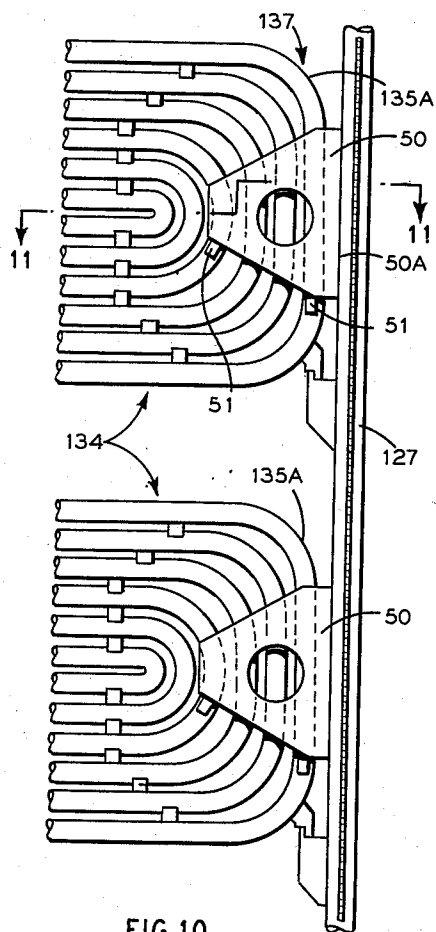
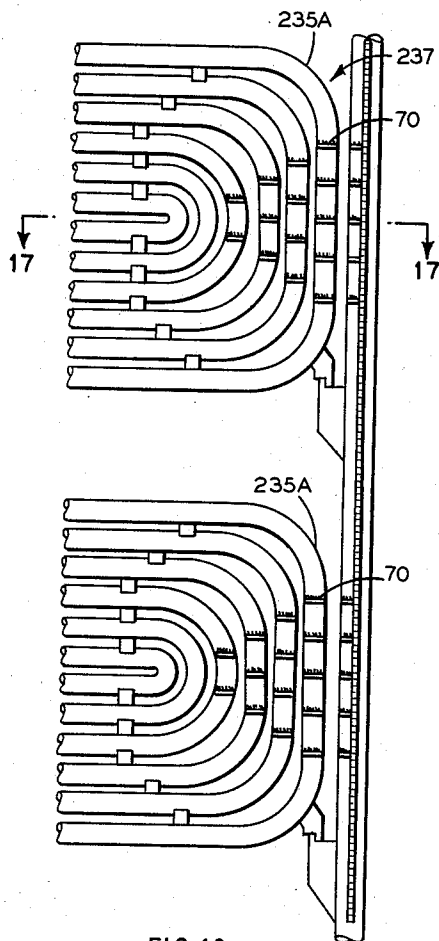
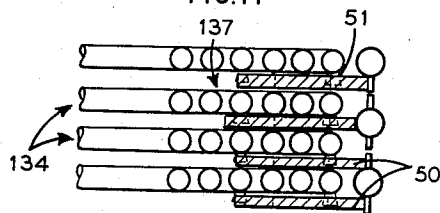


FIG. 16

FIG. 10

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FLUID HEATING UNITS

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10 Claims. (Cl. 257—230)

This invention relates in general to a fluid heat exchange apparatus, and more particularly to an improvement for minimizing the erosive effects of fly ash particles entrained in combustion gases on fluid heating tubes exposed to the same in vapor or steam generators adapted for burning solid ash bearing fuels.

The present invention is particularly applicable to vapor generators of the type which comprises essentially of an upright furnace chamber adapted to burn an ash bearing fuel, a laterally extending gas pass adjacent the upper end of the furnace chamber and a downwardly extending convection section connected thereto in which there is disposed a plurality of transversely extending, vertically aligned, spaced, side by side platen elements of horizontally extending multiple loop or return bend fluid heating tubes. In units of this type experience has shown that the flow of gases over the vertically disposed, spaced platen elements of horizontally extending fluid heating tubes is not uniformly distributed thereover, and that "laning" of the gases occurs along the walls of the convection section adjacent the bends of the tubes, i.e. a greater amount of the gases, by volume and weight, tends to flow along the walls of the convection section adjacent the tube bends, than will flow over the horizontally extended intermediate tube portions. This is due to the fact that the resistance to gas flow in the lanes adjacent the tube bends is less than the resistance to gas flow over and between the horizontally extended intermediate tube portions because of the vertical extent of the tubes at the bends. Consequently, a greater amount of the gases will be directed along the walls as the gases will normally flow along the path of least resistance.

When such generators are fired by solid ash bearing fuel, as for example coal or the like, particles of fly ash are often entrained in the combustion gases flowing from the furnace into the convection section and the velocity of the gases flowing through the convection pass causes the particles of fly ash to impinge on the tubes thereby subjecting the same to an erosion action. However, as a greater amount of gas by volume will tend to flow along the walls adjacent the tube bend, the amount of fly ash brought into contact with the tube bends is likewise increased so that a discernable condition of erosion is usually present at the tube bends.

This problem of erosion at the tube bends is materially aggravated when each tube bank consists of an arrangement of 4 or more nested return bend tubes in that the impedance to the gas flow adjacent the tube bends is greatly reduced due to the enlarged radii and extended vertical tube portions required to form the loops of the outermost nested tubes. Consequently, with the further reduction of resistance to gas flow, more of the gases are caused to flow through the lanes between tube bends together with more of the entrained ash particles which impinge on the tube bends, thereby increasing the erosive conditions thereat.

In vapor generators requiring the gases to make a turn

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in flowing from the furnace chamber to the convection pass, fly ash erosion along the tube bends adjacent the outside wall of the convection pass is further aggravated in that the percentage of fly ash entrained in the gases "laning" along the outside wall is increased over and above the amount of fly ash normally entrained in the "laning" gases due to the inertia separation of the fly ash from the gases as the latter make the turn.

An object of this invention is to minimize the above discussed erosion problem by impeding the flow of gases and entrained particles of fly ash in the lanes formed by adjacent tube platens in the convection section and thereby more uniformly distributing the gas flow throughout the entire area of the convection section.

Another object is to provide a relatively simple, inexpensive and easily fabricated means for accomplishing the desired result.

The objects and advantages of this invention are attained by disposing vertically extending barrier or baffle means having a predetermined contour in the lanes formed between adjacent tube platens, the barrier means having a width approximately equal to the clear space between platens. According to this invention the barriers are positioned adjacent the opposite convection gas pass walls next to the bends of the multiple loop fluid heating tubes and have portions thereof projecting inwardly therefrom into the spaces between the tube platens. The barriers extend inwardly from the wall a distance sufficient to impede the flow of gases "laning" in the spaces between adjacent tube bends. The arrangement is such that the gases which would normally tend to flow in the lanes formed in the vicinity of the tube bends of adjacent platens will be directed inwardly relative to the tube bends. This disturbance of the gas flow in the lanes between tube bends due to the barrier means adjacent the walls increases the resistance to gas flow therethrough. As a result the gas flow is more uniformly distributed across the entire area of the convection section and the concentration of entrained particles of fly ash in the gases is likewise more uniformly distributed. Thus any excessive erosion occurring at the tube bends is minimized.

A feature of this invention resides in the provision that the useful life of the fluid heating tubes, which are likely to be subjected to excessive fly-ash erosion, is extended. Because of this feature, the frequency and/or duration of unit shut-down for tube repairs due to fly-ash erosion is materially reduced.

Other features and advantages will be readily apparent when considered in view of the drawings and description in which:

Fig. 1 is a schematic showing of a partial vertical sectional side view of a typical steam generator embodying the present invention.

Fig. 2 is an enlarged diagrammatical showing of the convection pass section of the vapor generator of Fig. 1.

Fig. 3 is a perspective detail view of the fly-ash erosion barrier of the instant invention.

Fig. 4 is an enlarged view of detail A of Fig. 2.

Fig. 5 is a front view of Fig. 4.

Fig. 6 is an enlarged view of detail B of Fig. 2.

Fig. 7 is a front view of Fig. 6.

Fig. 8 is a sectional plan view taken along line 8—8 of Fig. 2.

Fig. 9 is a sectional plan view taken along line 9—9 of Fig. 2.

Fig. 10 is a fragmentary sectional side view illustrating an arrangement embodying a modified form of the invention.

Fig. 11 is a section view taken along line 11—11 of Fig. 10.

Fig. 12 is a detail side view of the modified form of the invention illustrated in Fig. 10.

Fig. 13 is a bottom view of the modified form of the invention illustrated in Fig. 12.

Fig. 14 is a detailed side view of another modified embodiment of the invention which may be adapted to the arrangement illustrated in Fig. 10.

Fig. 15 is a detail sectional view of the embodiment illustrated in Fig. 14 and taken along line 15—15 thereof.

Fig. 16 is a partial elevation sectional side view and arrangement utilizing still another embodiment of the present invention.

Fig. 17 is a section plan view taken along line 17—17 of Fig. 16.

Referring to Fig. 1 there is shown a steam generator 20 having a furnace chamber 21 generally defined by upright walls of steam generating tubes 22. A plurality of burners 23 firing an ash bearing fuel are arranged to generate hot products of combustion in the furnace chamber. The generating tubes 22 absorb a portion of the radiant heat emitted by the combustion gases and the steam generated thereby together with the remaining fraction of the water supplied to the walls discharges into the steam and water separating drum 24. Adjacent the upper end of the furnace chamber 21 is a gas exit in communication with a connected lateral gas pass 25 defining a flow path for the combustion gases flowing from the furnace chamber 21 to a convection downflow gas pass 26 which is connected thereto. As shown the convection pass 26 is formed by walls including tubular fluid cooling elements 27 which are generally spaced and studded and provided with an outer covering refractory insulation (not shown).

In units of the type described steam heating tubes are disposed in the lateral gas pass 25 and downpass 26 and are heated by convection as the hot gases flow thereover. As shown, the first and second portions 28, 29 respectively of the primary steam superheater and/or reheater 30, are exposed to the gas flow with section 28 being disposed in the convection downpass 26 and a secondary superheater 31 generally positioned in the lateral gas pass 25. With this arrangement saturated steam is delivered from the drum 24 to an inlet heater 32 and flows through the first portion 28 of the primary superheater, thence through the second portion 29 thereof and finally through the secondary superheater 31, discharging into outlet header 33.

Referring to Figs. 1, 2 and 8 and 9 the first portion 28 of the primary superheater 30 in the convection pass 26 includes a plurality of transversely extending, vertically arranged, spaced, side by side platens 34 of horizontally extending nested, multiple loop or return bend tubes 35, each tube platen being supported at its opposite outer bends on the adjacent wall by a plurality of vertically spaced pairs of support brackets 36.

In a steam generator as above described in which the tube platens 34 extend transversely with respect to the flow of the convection heating gases, experience has shown that a greater percentage of gases by volume or weight tends to flow over the tube bends 35A adjacent the walls, than over the horizontal straights 35B of the tubes. Since the gases carry with them entrained particles of fly ash, the impact of the particles on the tubes 35 due to the velocity of the gases flowing thereover subjects the tubes 35 to an erosive action. The erosion on the tube ends 35A being especially critical in that a relatively greater quantity of the fly ash particles impinge thereon due to "laning" of the greater amounts of gases through the spaces or lanes 37 formed between the tube platens at the tube bends. Where the number of nested tubes is increased, for example to more than four, as viewed in Figs. 10 and 16, laning of the gases at the tube bends becomes aggravated and in effect reduces the resistance to gas flow still further, resulting in increasing the problem of erosion on the tube ends.

To overcome excessive erosive conditions on the tube bends, barrier or baffle means are vertically disposed in

the lanes 37 between tube platens 34 to impede or restrict the flow of gases therethrough and thereby more uniformly distribute the gases and the entrained erosion causing ash particles, as well, across the entire area of the convection pass.

In one embodiment of this invention, as shown in Figs. 2 to 9, the barrier means consists of an elongated bar 38 which may be of any predeterminate length as shown in Figs. 1, 2 and 3. Accordingly, the bars 38 are secured to the wall adjacent the tube bends 35A and are shaped so as to project inwardly from the wall and into the lanes 37 formed between tube bends of adjacent platens 34. The arrangement is such that in the vicinity of the tube bends 35A the barriers project inwardly over a major portion of the lane extending between the innermost tube bends of the platens and the adjacent gas pass wall, as shown in Figs. 2, 10 and 16.

In the illustrated form, as typified in Fig. 3, each barrier is formed of a high heat resistant, alloy metal, flat bar 38 of a predeterminate length. Each end of the bar is provided with mounting portions 38A and 38B. An aperture 38C, 38D in each end receives a pin 39 by which it is secured to the wall of the convection pass; one aperture 38D being elongated to provide for thermal expansion of the bar 38 when heated. If desired the bars may be welded to the walls.

The intermediate portion 40 of the bar 38 as shown in Figs. 2 and 3 is zig-zag, sinuous or otherwise suitably shaped with the crest portion 40A thereof extending inwardly of the wall and projecting into the lanes 37 between adjacent tube platens. Depending on the vertical extent of a tube platen 34, one or more of these zig-zag or corrugated barriers may be vertically arranged throughout the vertical height of the lane 37 formed between the tube bends of adjacent platens 34; the widths of the barrier being approximately equal to the clear space between platens. In the event the tube platens are closely spaced, for example one inch clear spaces between platens, the barrier may be formed of round bar stock.

As shown in Figs. 2 to 7 the apertures 38C, 38D in the mounting portions are aligned with pins or studs 39 welded to the wall, and the pin receivable in the elongated aperture 38D being placed at an elevation that will place it at the bottom of the elongated aperture 38D in the cold position. A washer 41 welded to the outer end of each pin 39 secures the bar.

In operation the sinuous bars 38 projecting into the lanes 37 between tube platens restrict the gas flow and increase the resistance thereof. Thus less gas is channeled through the lanes 37 and consequently the amount of entrained particles flowing therein is materially reduced. The end result is reduced "laning" at the tube bends and the gases more uniformly distributed over the entire area of the downpass. The proximity of the bars 38 to the fluid cooling tubes 27 in the walls and the adjacent loop tubes 35A together with cavity radiation from the wall tubes effect a cooling condition sufficient to maintain temperature of the bars 38 within satisfactory use limits.

Another embodiment of this invention, as shown in the arrangement of Fig. 10 consists of vertically disposing a plurality of spaced, suitably shaped tile members 50 in the lanes 137 between tube platens 134 to restrict the flow of gases therethrough. As shown in Figs. 10, 12 and 13 the tiles are substantially triangular or trapezoidal in shape and are formed of a ceramic or refractory material. Lugs 51 connected to and projecting laterally from the nested tube bends 135A are arranged to support the tile within the lanes, the base portion 50A of the tile being vertically disposed in engagement with the wall 127.

Figs. 14 and 15 illustrate another modified form of tile 60 which may be utilized in the arrangement of Fig. 10. As shown tile 60 consists of a casting made of suitable high heat resistant, alloy metal which is likewise substantially triangular or trapezoidal in shape and has a

laterally extending peripheral flange 60A, the flange 60A being approximately as wide as the clear space between adjacent tube platens.

Figs. 16 and 17 illustrate still another embodiment of the invention. In this form the barrier means consists of a plurality of laterally extending stud plates 70 welded to the nested tubes at the bends 235A thereof. The arrangement of the welded stud plates 70, as shown in Fig. 16 are staggered and stepped with the stepped arrangement converging inwardly of the convection wall adjacent the tube bends. The arrangement is such that the flow of gases through lane 237 is impeded for the reasons hereinafter described.

While the instant invention has been described with specific reference to erosion due to fly ash particles, it is to be noted that the term "fly ash" where used is intended to include cinder particles or other solid granular particles of different sizings which would tend to have an erosive effect on fluid heating tubes exposed thereto and it is to be appreciated that the invention is not to be taken as limited to all of the details thereof as modifications and variations thereof may be made without departing from the spirit or scope of the invention.

What is claimed is:

1. In a vapor generator, fluid cooled walls defining a gas pass through which combustion gases having entrained particles of fly ash flow, a plurality of spaced tube elements of horizontally extending return bend tubes disposed in said gas pass, the return bends of said tubes being disposed adjacent opposite walls of said gas pass substantially normal thereto, barrier means vertically disposed in lanes formed between adjacent tube elements, said barrier means consisting of a plurality of vertically spaced substantially triangular members having the base portion thereof adjacent to said walls and the apex portion thereof extending inwardly from said walls adjacent the tube bends, said member traversing the major portion of the distance between the innermost tube bend and the adjacent wall to impede the laning of said gases along the said adjacent wall in the vicinity of said tube bends for minimizing the fly-ash erosion thereof.

2. The invention as defined in claim 1 wherein said barrier means are formed of a plurality of vertically spaced refractory tiles and laterally projecting lugs connected to said tubes for supporting each of said tiles between adjacent tube elements.

3. The invention as defined in claim 1 wherein said barrier means is formed of a plurality of alloy castings and laterally projecting lugs connected to said tubes for supporting each of said castings between adjacent platens.

4. In a vapor generator, wall means defining a gas pass through which combustion gases having entrained particles of fly ash flow, a plurality of vertically disposed, spaced platens of horizontally extending, nested, multiple-looped tubes disposed in said gas pass, the multiple looped ends of said nested tubes being disposed adjacent opposite walls of said gas pass and extending substantially normal thereto, barrier means vertically disposed in lanes formed between tube platens and adjacent the looped end of said tubes, said barrier means including laterally extending, vertically spaced stud plates connected to the looped end of said nested tubes in a pattern to impede the laning of said gases in the lanes between the multiple loop tube ends adjacent the walls to minimize fly-ash erosion of the looped end of said tubes.

5. In a vapor generator, wall means defining a gas pass through which combustion gases having entrained particles of fly-ash flow, a plurality of vertically disposed spaced platens of horizontally extending, nested, multiple-looped tubes disposed in said gas pass, the multiple looped ends of said nested tubes being disposed adjacent opposite walls of said gas pass and extend substantially normal thereto, a plurality of barrier forming means vertically spaced and disposed in lanes formed between tube platens adjacent the looped end of said tubes, each of said barrier means including laterally extending vertical-

ly spaced stud plates connected to the looped end of said nested tubes, said plates being connected to the successive nested tube loops in stepped relationship to each other to form an inwardly converging pattern to impede the laning of said gases in the lanes between the adjacent banks of multiple loop tube ends at the walls to minimize fly ash erosion of the looped end of said tubes.

6. In a vapor generator, fluid cooled walls defining a gas pass through which combustion gases having entrained particles of fly ash flow, a plurality of vertically disposed spaced tube platens of horizontally extending nested multiple looped tubes, the loops of said tubes being disposed adjacent opposite walls of said gas pass, barrier means vertically disposed in lanes formed between adjacent tube platens, said barrier means comprising an elongated bar having its end portions connected to the wall adjacent the loops of said tubes and an intermediate portion between said connected ends contoured to extend inwardly from said wall in the vicinity of said tube-loops the major portion of the distance between the outermost and innermost tube loop of said nested tubes to impede the flow of gas adjacent the looped ends of said tubes.

7. In a vapor generator, fluid cooled walls defining a gas pass through which combustion gases having entrained particles of fly ash flow, a plurality of vertically disposed spaced tube platens of horizontally extending nested multiple-looped tubes, the loops of said tubes being disposed adjacent opposite walls of said gas pass, barrier means vertically disposed in lanes formed between adjacent tube platens, said barrier means comprising an elongated bar having its end portions connected to the wall adjacent the loops of said tubes and an intermediate portion between said connected ends having a corrugated contour having its crest portions extending inwardly from said wall adjacent said tube loops the major portion of the distance between the outermost and innermost loops of said nested tubes to impede the flow of gas along said nested loops.

8. For use in a fluid heating unit including a gas pass having opposed walls for containing a flow of heating gases with entrained particles of fly ash and having vertically disposed therein a plurality of spaced tube platens of horizontally extending nested return bend tubes exposed in heat absorbing relationship with said gases in which the planes of said platens are disposed substantially normal to said walls with the return bends spaced from said walls, the improvement of zig-zag baffle means connected to said walls in the spaced intervals formed between adjacent pairs of said platens, said baffle means having extending portions projecting radially inwardly into the spaces formed between platens with respect to said return tube bends whereby said projecting portions are disposed alongside the return bends of the adjacent platens and extend into said space a major portion of the distance between the outermost and innermost tube bend of said nested tubes for impeding the flow of gases laning through the spaces formed by adjacent pairs of return bends of said platens.

9. In a vapor generator, front, rear and connected side walls defining a gas pass through which combustion gases having entrained particles of fly ash flow, a plurality of vertically disposed horizontally spaced tube platens disposed in said gas pass so that the plane of each platen is substantially normal to said front and rear wall, said platens including horizontally extending, nested, return bend tubes, the return bends of said tubes being spaced from said front and rear wall, a plurality of vertically disposed elongated zig-zag baffle means connected to said front and rear walls in the spaced intervals between platens, said zig-zag baffle means extending inwardly from said walls into the spaces formed between adjacent platens and opposite the return bends of said platens, said baffle means extending inwardly the major portion of the distance between the outermost and innermost tube bend to said nested tubes to impede the flow of gases

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laning through the spaces formed adjacent the return bends of said platens.

10. In a vapor generator, front, rear and connected side walls defining a gas pass through which combustion gases having entrained particles of fly ash flow, a plurality of vertically disposed horizontally spaced tube platens disposed in said gas pass so that the plane of each platen is substantially normal to said front and rear wall, said platens including horizontally extending, nested, return bend tubes, the return bends of said tubes being spaced from said front and rear wall, a plurality of vertically disposed zig-zag baffle means connected to said front and rear walls in the spaced intervals between platens, said zig-zag baffle means comprising an elongated bar having a plurality of spaced inwardly converging intermedite portions extending inwardly of said walls into the spaced intervals formed between adjacent

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platens whereby said converging portions are disposed opposite the return bends of said platens, said converging portions extending inwardly the major portion of the distance between the outermost and innermost tube bend to said nested tubes to impede the flow of gases laning through the space formed between adjacent pairs of said platens.

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