March 1, 1966 P. H. KOCH ET AL 3,237,612

FORCED FLOW VAPOR GENERATING UNIT

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FIG. 1

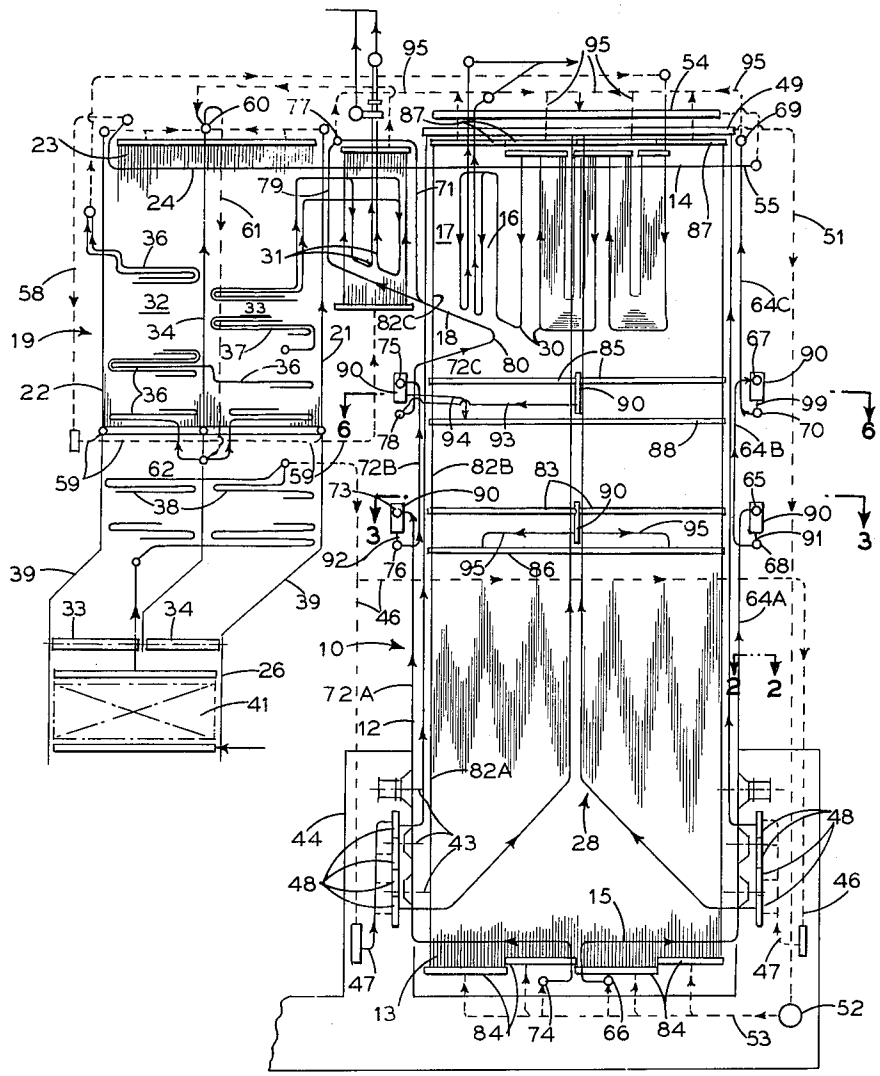
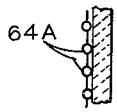


FIG. 2



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FIG. 3

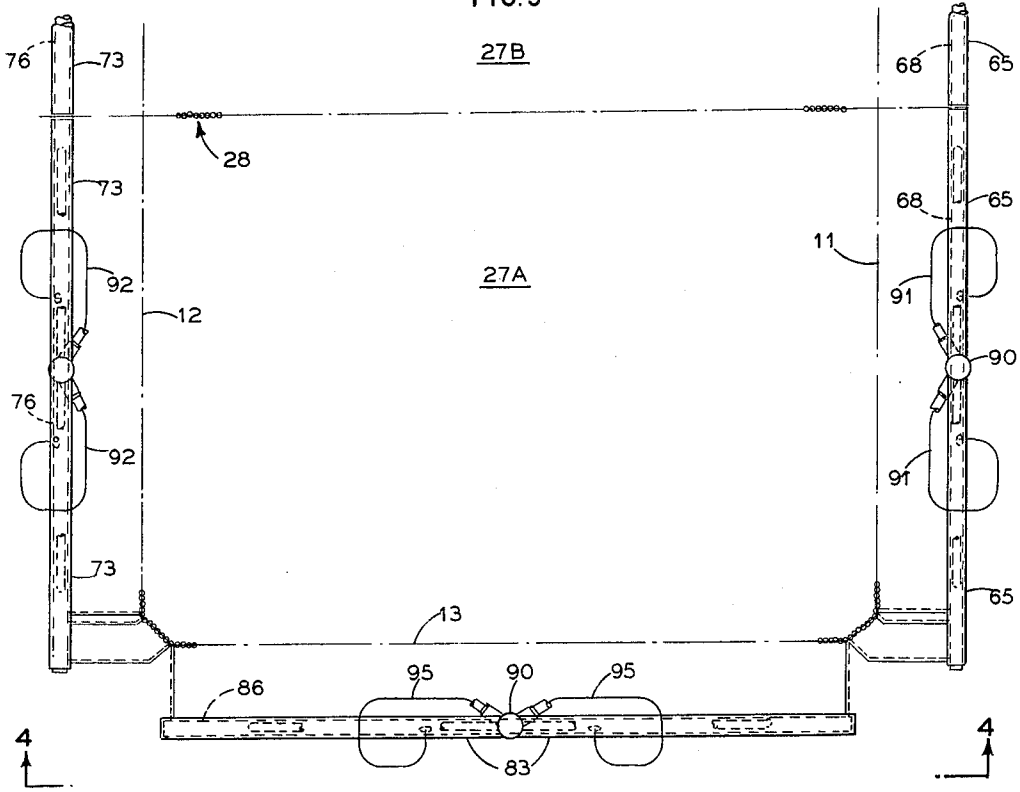


FIG. 4

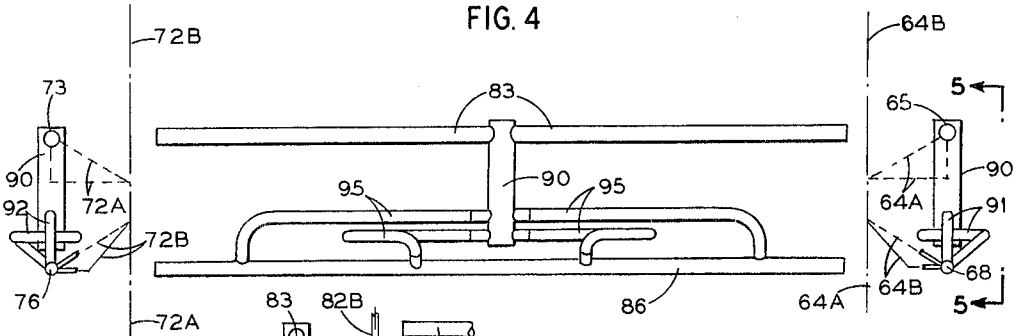
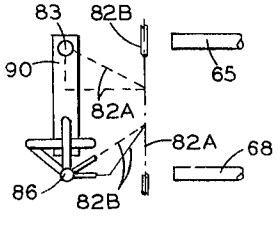


FIG. 5



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FIG. 6

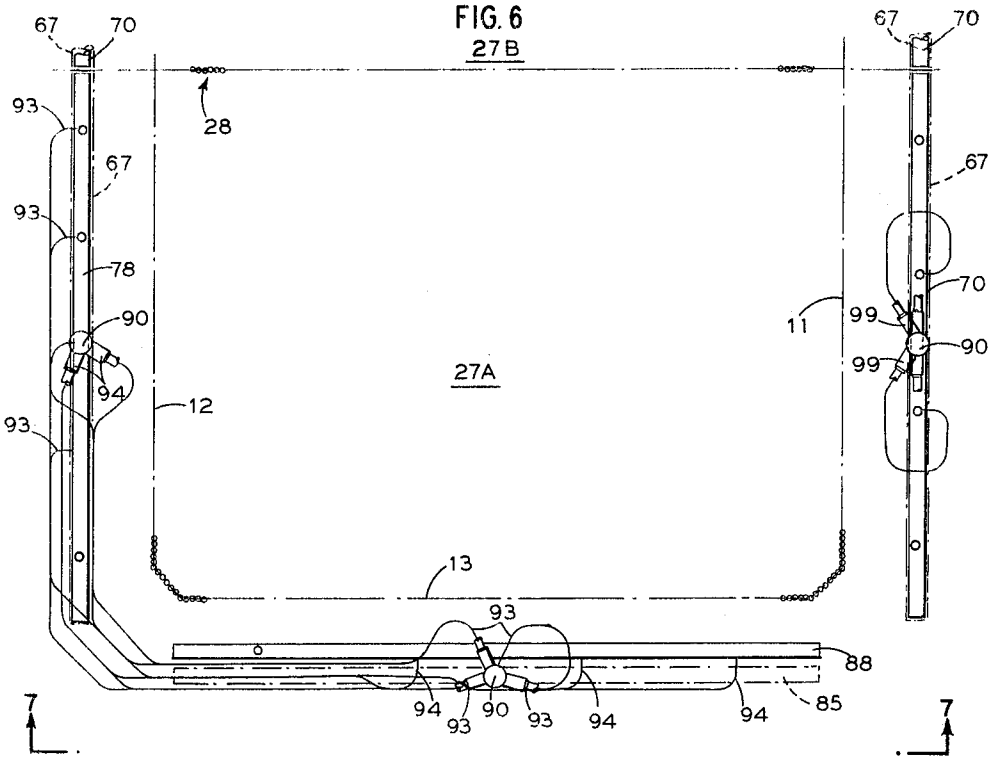
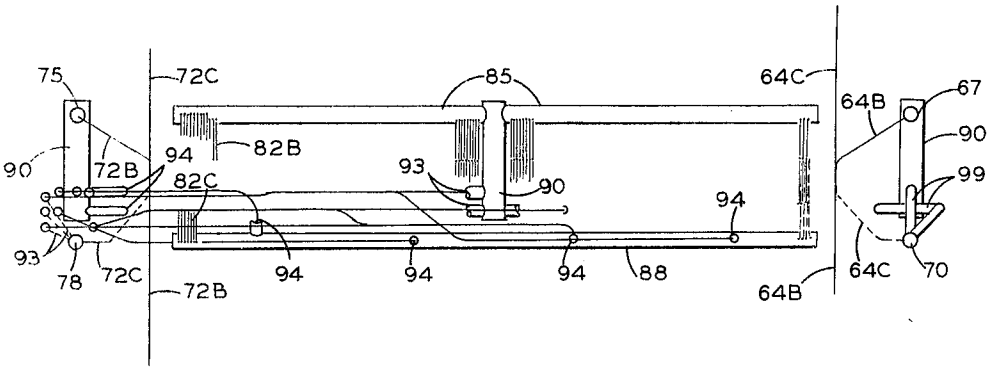


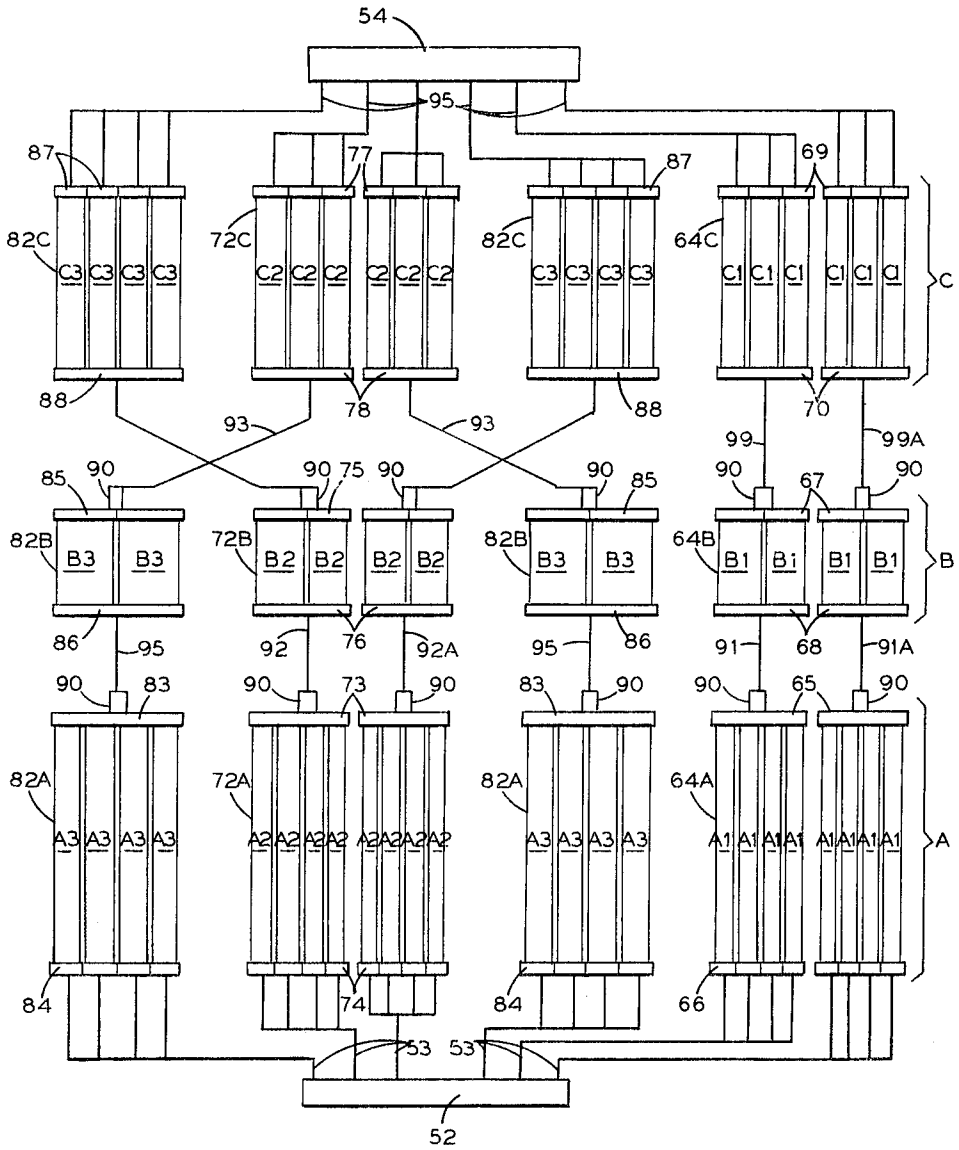
FIG. 7



FORCED FLOW VAPOR GENERATING UNIT

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FIG. 8



United States Patent Office

3,237,612
Patented Mar. 1, 1966

3,237,612

FORCED FLOW VAPOR GENERATING UNIT

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Filed Oct. 1, 1963, Ser. No. 313,002
10 Claims. (Cl. 122—406)

The present invention relates in general to the construction and operation of a forced flow fluid heating unit and more particularly to improvements in the construction and arrangement of fluid heating circuits especially adapted for use in a forced circulation once-through steam generating and superheating unit.

The construction of forced circulation once-through steam generators requires the use of a large number of parallel flow circuits connected between inlet and outlet headers. One of the fundamental problems involved with such a steam generator is the control of the flow through the various parallel flow circuits in order that the flow in each circuit will be stable and the enthalpy of the fluid discharged from any individual circuit will be close to the average of that from all circuits in which case the circuit will be in a balanced flow condition. Unbalanced flow may be caused by unequal heat absorption in parallel flow circuits due to an unsymmetrical arrangement of heating surface, slag accumulation, or part-load operation with burners out of service; or may be due to unequal resistances caused by different lengths of circuits. When steam or water, or mixtures thereof, is heated in parallel flow paths provided by the furnace wall tubes or tubular panels disposed in the furnace, unbalanced heat and/or fluid flow distribution may lead to excessive localized tube metal temperature and/or to excessive temperature differentials between adjacent furnace wall tubes and, thereby, to undue thermal stresses in the furnace wall-forming components. The problem of unequal fluid flow distribution is accentuated when the fluid supplied to high heat absorbing parallel flow circuits of the furnace is a mixture of steam and water. Whenever a steam-water mixture must be distributed to many tubes of parallel flow circuits, the possibility of separation of the steam-water mixture exists. Thus one tube may receive saturated steam and another tube may receive saturated water or any combination of the two components. Such a condition imposes a limit on the rate of heat absorption that the tubes of the parallel flow circuits can tolerate without exceeding allowable metal temperature or allowable temperature differences between adjacent tubes.

The present invention solves the foregoing problems by subdividing the furnace boundary walls into a plurality of fluid heating passes and by special provisions for mixing the heat absorbing medium as it flows from one of the fluid heating passes to another of the fluid heating passes. In accordance with the invention a unit of the character described the upright boundary walls of the furnace are subdivided into a plurality of separate continuous upflow fluid heating passes, each wall of each pass including a row of upwardly extending parallel flow tubes arranged in groups to form parallel flow tube panels extending between upper and lower headers, with special provisions for interconnecting the tube panels of the fluid heating passes to provide a serial flow of fluid successively through the respective fluid heating passes and for mixing the fluids to equalize fluid enthalpies as they flow from one furnace fluid heating pass to another.

The various features of novelty which characterize this invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention its operating features and specific objects attained by its use, reference

should be had to the accompanying drawings and descriptive matter in which is illustrated and described a preferred embodiment of the invention.

Of the drawings:

FIG. 1 is a diagrammatic sectional elevation of a forced circulation once-through steam generating unit constructed and operable in accordance with the invention, with a showing of the vaporizable fluid flow path of the unit;

FIG. 2 is a plan section taken along the line 2—2 of FIG. 1;

FIG. 3 is a partial sectional plan view taken along the line 3—3 of FIG. 1;

FIG. 4 is a side view along line 4—4 of FIG. 3;

FIG. 5 is a partial side view along the line 5—5 of FIG. 4;

FIG. 6 is a partial sectional plan view taken along the line 6—6 of FIG. 2;

FIG. 7 is a side view taken along line 7—7 of FIG. 6; and

FIG. 8 is a diagrammatic representation of the tube panels of the fluid heating passes of the furnace boundary walls and of the vaporizable fluid flow path through the fluid heating passes.

In the drawings the invention has been illustrated as embodied in a top-supported forced flow once-through steam generating unit intended for central station use. The particular unit illustrated is designed on coal firing for maximum continuous steam output of 2,200,000 lbs. of steam per hour at a pressure of 2403 p.s.i.g. at a total temperature of 1100° F. at the superheater outlet based on feedwater being supplied at a pressure of 3130 p.s.i.g. and a temperature of 530° F.; and a maximum continuous steam output of 1,870,000 lbs. of steam per hour at a pressure of 525 p.s.i.g. and a total temperature of 1050° F. at the reheater outlet.

The main portions of the unit illustrated include an upright furnace chamber 10 of substantially rectangular cross-section defined by front wall 11, rear wall 12, side walls 13, roof 14, and floor 15 and having a gas outlet 16 at its upper end opening to a horizontally extending gas pass 17 of rectangular vertical cross-section formed by a floor 18 and extensions of the furnace roof 14 and side walls 13. Gas pass 17 communicates at its rear end with the upper end of an upright gas passage 19 of rectangular horizontal cross-section formed by a front wall 21, rear wall 22, side walls 23 and roof 24, and communicating at its discharge end with an upright gas passage 26. The furnace 10 is divided into a pair of compartments 27A, 27B by a vertical partition wall 28, each compartment opening at its upper end to the gas outlet 16 with the upper portion of wall 28 also dividing the gas inlet end of the pass 17 into parallel heating passes or sections forming continuations of compartments 27A and 27B.

A secondary superheater 30 is disposed in part in the upper portion of the furnace 10 adjacent the gas outlet 16 thereof, with the remainder occupying the furnace end of the gas pass 17 is occupied by a secondary reheater 31.

Upright gas passage 19 is divided into parallel heating gas passes or sections 32 and 33 by a vertical baffle 34 with the upper part of gas pass 32 and the lower part of gas passes 32 and 33 being occupied by a primary superheater 36, the upper part of gas pass 33 by primary reheater 37, and the lower part of gas passes 32 and 33 by a secondary economizer 38 disposed downstream gas-flow wise of superheater 36. The discharge end of gas passes 32 and 33 are connected by ducts 39 to the inlet end of gas pass 26. Proportioning of the gas flow between the gas passes 32 and 33 is controlled by dampers 33 and 34 at the discharge end of the ducts 39. Gas pass 26 is occupied by a primary economizer 41. After

flowing through the pass 26 and over the economizer surface therein, the heating gases pass through an air heater, not shown, and thence to a stack.

The lower portion of the compartments 27A, 27B of the furnace 10 are fired by horizontally extending burners 43 arranged to direct fuel and air in mixing relation into the compartments through corresponding burner ports in the boundary walls of the furnace. Preheated air is supplied to the burners by a forced draft fan not shown, which passes air under pressure through the air heater and suitable ductwork to a windbox 44 enclosing the burners 43 and the lower portion of the front and rear boundary walls of the furnace 10.

In operation high pressure fluid supplied by a feed pump, not shown, passes successively through economizers 41 and 38, and then flows through a pair of downcomers 46 and supply tubes 47 to the inlet headers for partition wall 28 of the furnace.

Partition wall 28 is formed by a row of vertically extending parallel tubes arranged in groups to form coplanar radiant heat absorbing tube panels extending between lower inlet headers 48 and a common upper outlet header 49, with headers 48 being connected for supply of fluid from downcomers 46 by tubes 47. From the header 49 the fluid passes through a downcomer 51 to a fluid mixing and distribution system constructed and arranged in a manner similar to that described in the copending application of Paul H. Koch, Serial No. 45,649 filed July 27, 1960. This system comprises a hollow spherical vessel 52 connected to the discharge end of the downcomer 51 and arranged to discharge fluid in parallel flow relation to supply tubes 53 communicating with the furnace boundary wall fluid heating circuitry, which will be hereinafter described. From the furnace boundary wall fluid heating circuitry the fluid passes to a common mixing header 54, then flows through tubes 55 forming the roof of furnace 10 and gas passes 17 and 19 to a header 56, and then passes through a pair of downcomers 58 and supply tubes 59 for distribution to fluid heating circuitry of gas passes 17 and 19.

The boundary and partition walls of gas pass 19 and of the side walls of the gas discharge end of gas pass 17 are lined by fluid heating tubes constructed and arranged so that the fluid supplied by tubes 59 flows upwardly in parallel through the convection heat absorbing fluid heating tubes of the boundary and partition walls of the gas pass 19 and of the side walls of the gas discharge end of the gas pass 17, and then to a common fluid collection and distribution header 60. From header 60 the fluid flows through a pair of downcomers 61 to an inlet header 62 for primary superheater 36, and then successively passes through primary superheater 36 and secondary superheater 30 to the high pressure stage of a vapor turbine, not shown. Partially expanded steam from the turbine passes successively through reheater 37 and reheater 31, and then returns to the turbine for final expansion.

The fluid heating surfaces of the unit are proportioned and arranged so that throughout the operating range the portion of the heated fluid circuit in which the transition of the fluid from a water condition to a vapor-water condition will be located in the furnace wall fluid heating passes hereinafter described and the portion of the heated fluid circuit in which the transition of the fluid from a vapor-water condition to a vapor condition will be located in the relatively low temperature primary superheater 36.

In accordance with the invention, and with particular reference to FIGS. 1 and 8, the upright boundary walls of the furnace are divided into three separate upflow fluid heating passes A, B and C, each wall of each pass comprising a row of insulation covered parallel flow tubes having their intertube spaces closed by metallic webs welded to adjacent tubes to provide a gas-tight construction, as shown in FIG. 2, and arranged in groups to form coplanar radiant heat absorbing parallel flow tube panels extending between horizontally arranged upper and lower headers, with special provisions for mixing the heat absorbing medium as it flows from one pass to another. The mixing system between each of the furnace fluid heating passes is used to keep the wall tube temperature difference to a minimum. With differences of furnace cleanliness and variation of flow quantities in the parallel flow tubes of a pass it is possible to develop a temperature difference between adjacent tubes of a magnitude placing high stresses on the tubes and the metallic webs therebetween. By limiting the magnitude of the B.t.u. pick-up in any furnace fluid heating pass the size of the unbalance is also limited. Accordingly, the furnace boundary wall fluid heating surface is so proportioned and arranged that the temperature of the fluid in a furnace wall tube at any furnace level is no greater than 100° F. above the average fluid temperature of all furnace wall tubes at that level, thereby maintaining differential expansion of the wall-forming components within safe limits.

Thus one half of the floor 15 and the lower half of front wall 11 are formed by a row of tubes 64A arranged in groups to form tube panels A1 extending between upper and lower headers 65 and 66; the middle portion of front wall 11 is formed by a row of tubes 64B arranged in groups to form tube panels B1 extending between upper and lower headers 67 and 68; and the upper portion of front wall 11 is formed by a row of tubes 64C arranged in groups to form tube panels C1 extending between upper and lower headers 69 and 70.

The other half of floor 15 and rear wall 12 are formed by a row of tubes 72A arranged in groups to form tube panels A2 extending between upper and lower headers 73 and 74; the middle portion of rear wall 12 is formed by a row of tubes 72B arranged in groups to form tube panels B2 extending between upper and lower headers 75 and 76; and the remainder of rear wall 12 is formed by a row of tubes 72C arranged in groups to form tube panels C2 extending between upper and lower headers 77 and 78. Tubes 72C have extensions bent inwardly and upwardly to form a nose arch 80 and then rearwardly and upwardly to form a portion of the flow of gas pass 17, with some of the tubes of each panel C2 then continuing vertically upward at a position intermediate reheater 31 and superheater 30 for connection to headers 77 and to form a gas screen 71 and the remaining tubes of each panel C2 continuing rearwardly and upwardly to form the remainder of the floor of gas pass 17 and then vertically upward for connection to headers 77 and to form another gas screen 79. Tubes 72C have their intertube spaces closed by metallic webs up to the midpoint of the floor of gas pass 17, while the tube portion forming the remainder of the flow of gas pass 17 have their intertube spaces closed by refractory covered flat studs.

The lower half of each side wall 13 is formed by a row of tubes 82A arranged in groups to form tube panels A3 extending between upper and lower headers 83 and 84; the middle portion of each side wall by a row of tubes 82B arranged in groups to form tube panels B3 extending between upper and lower headers 85 and 86; and the upper portion of each side wall is formed by a row of tubes 82C arranged in groups to form tube panels C3 extending between upper and lower headers 87 and 88.

From the above description it is evident that tube panels A1, A2, A3 constitute the first fluid heating pass A of the furnace, tube panels B1, B2, B3 the second fluid heating pass B, and tube panels C1, C2, C3 the third fluid heating pass C. Tube panels of each wall of each pass and their corresponding inlet and outlet headers are symmetrically arranged on opposite sides of the vertical centerline of the corresponding wall.

The height of the tube panels of each fluid heating pass of the furnace boundary walls is set so that in the event

of unbalanced heat and/or fluid flow the temperature of the fluid leaving any tube of a fluid heating pass is no greater than 100° F. above the average fluid temperature of the fluid leaving the corresponding pass to prevent the possibility of undue thermal stresses between laterally adjacent tubes. Thus each fluid heating pass of the furnace boundary walls extends upwardly to the point where this temperature differential would be reached under the most adverse heat and fluid flow distribution conditions that would be encountered, at which point the fluids discharging from the heating pass are collected, mixed to neutralize the difference in amount of heat picked up, and then distributed to parallel flow tubes of the next fluid heating pass. For this purpose tube panels of the fluid heating passes of the furnace are interconnected to provide a serial flow of fluid successively through the tube panels of pass A, pass B and pass C and to provide mixing of the fluids as they flow from one furnace fluid heating pass to another. Accordingly, an upright substantially cylindrical fluid mixing vessel **90** is provided outside of the furnace enclosure at the following locations: each side wall **13**, along the vertical centerline of the wall intermediate headers **83** and **86** and intermediate headers **85** and **88**; front wall, intermediate headers **65** and **68** on the same side of the vertical centerline of the wall, intermediate headers **65** and **68** on the opposite side of the vertical centerline of the wall, intermediate headers **67** and **70** on the same side of the vertical centerline of the wall, and intermediate headers **67** and **70** on the opposite side of the vertical centerline of the wall; rear wall, intermediate headers **73** and **76** on the same side of the vertical centerline of the wall, intermediate headers **73** and **76** on the opposite side of the vertical centerline of the wall, intermediate headers **75** and **78** on the same side of the vertical centerline of the wall, and intermediate headers **75** and **78** on the opposite side of the vertical centerline of the wall. Thus each side wall **13** comprises two mixing devices **90**, one between passes A and B, the other between passes B and C; and front wall **11** and rear wall **12** each comprises four mixing devices, two between passes A and B, and two between passes B and C.

Since the construction and arrangement of the fluid collection and mixing systems and their associated tube panels are essentially the same at all locations, the construction and arrangement of only one of the side wall systems and its associated tube panels will be described. So, with reference to FIGS. 4 and 5, the discharge portions of tubes **82A** of panels A3 are bent outwardly from the plane of the wall at a level intermediate headers **83** and **86** and upwardly for radial connection to corresponding headers **83**, with each of the headers **83** being radially connected and opening at one end to the upper portion of corresponding mixing vessel **90**. Inlet portions of tubes **82B** of panels B3 extend radially from corresponding header **86** and generally upwardly to enter side wall **13** at a level intermediate headers **83** and **86** and subjacent the level at which the discharge portions of tubes **82A** bend outwardly, and then extend upwardly in the plane of the wall in the spaces between and contiguous to the discharge portions of tubes **82A**.

With particular reference to FIGS. 3–5 and 8, the interconnection of tube panels of the first and second fluid heating passes A and B is completed by fluid distribution tubes leading radially from the lower portion of each mixing device **90** for distributing the mixed fluids received from tube panels of each wall of the first fluid heating pass A to tube panels of the corresponding wall of the second fluid heating pass B. Thus panels A1 on one side of the vertical centerline of front wall **11** are connected for series flow of fluid to panels B1 on the same side of the vertical centerline of the wall **11** by fluid distribution tubes **91** extending between corresponding mixing device **90** and header **68**, while panels A1 on the opposite side of the vertical centerline of wall **11** are connected for series flow of fluid to panels B1 on the corresponding side of the vertical centerline of wall **11** by fluid distribution tubes **91A** extending between corresponding mixing device **90** and header **68**. Likewise, tubes **92** and **92A** complete the interconnection of panels A2 on the same side of the vertical centerline of rear wall **12** to the panels B2 on the corresponding side of the vertical centerline of wall **12**, with tubes **92** and **92A** leading from corresponding mixing devices **90** to corresponding headers **76**. Panels A3 of each side wall are serially interconnected with panels B3 of the corresponding wall by fluid distribution tubes **95** extending between corresponding mixing device **90** and header **86**.

In order to maintain a balance between the heat pick-up of the four furnace walls one extra step has been taken at the mixing system between the second and third furnace fluid heating passes B and C. Up to this point it is expected that fluid flow balances and heat pick-up should have been substantially uniform. Above this point the circuitry of rear wall **12** changes character. The length, as well as the bend resistance, of tubes **72C** of panels C2 of fluid heating pass C of rear wall **12** are considerably increased compared to the lengths and bend resistances of the corresponding tubes of the side and front walls of pass C. In order to balance out this difference the fluid flow from panels B3 of each side wall **13** is transferred around to the panels C2 of the adjacent half, with respect to the vertical centerline of rear wall **12**. This places a greater fluid quantity to the higher heat pick-up circuit represented by panels C2. Meanwhile, the fluid discharging from panels B2 of rear wall **12** is uniformly distributed to panels C3 of side walls **13**; and fluid discharging from panels B1 of front wall **11** is transferred to panels C1 of the corresponding wall. Consequently, and with particular reference to FIGS. 6–8, panels B3 of each side wall **13** are connected for series flow of fluid to panels C2 of the adjacent half, with respect to the vertical centerline, of rear wall **12** by fluid distribution tubes **93** extending between corresponding mixing device **90** and header **78**. Panels B2 on the same side of the vertical centerline of rear wall **12** are connected for series flow of fluid to panels C3 of the adjacent side wall **13** by fluid distribution tubes **94** extending between corresponding mixing device **90** and header **88**. Panels B1 on one side of the vertical centerline of front wall **11** are connected for series flow of fluid to panels C1 on the same side of the vertical centerline of the wall by fluid distribution tubes **99** extending between corresponding mixing device **90** and header **70**, while panels B1 on the opposite side of the vertical centerline of the wall are connected for series flow of fluid to panels C1 on the corresponding side of the wall by tubes **99A** extending between corresponding mixing device **90** and header **70**.

In operation high pressure fluid in a subcooled condition is passed in parallel flow relation from vessel **52** to tube panels A1, A2, A3 of fluid heating gas pass A by way of supply tubes **53**, with the fluid discharging from panels A1 successively passing through panels B1 and C1, the fluid discharging from panels A2 passing in parrallel through panels B2 and then dividing for parallel flow through panels C3 of the side walls, and the fluid discharging from panels A3 of each side wall successively passing through panels B3 of the corresponding wall and panels C2. Headers **69**, **77** and **87** are connected for flow of fluid to mixing header **54** by way of tubes **95**.

By way of example, and not of limitation, the tubes of the first fluid heating pass are ⅞" O.D. on 1½" centerlines, the front and rear walls of this pass each having 343 tubes and each side wall 207 tubes; the tubes of the second fluid heating pass B are ⅞" O.D. on 1½" centerlines, the front and rear walls of this pass having 344 tubes and each side wall 207 tubes; and the tubes of the third fluid heating pass C are 1" O.D., with the tubes of

the front and side walls and the rear wall up to the midpoint of the floor of gas pass 17 being on 1½" centerlines, the remainder of the floor tubes of gas pass 17 on 2" centerlines, the tube portions forming screen 79 on 4½" centerlines, and the tube portions forming screen 71 on 6" centerlines, and with the front wall having 343 tubes, each side wall 207 tubes, and the rear 343 tubes of which 260 cooperate to form screen 79 and 83 cooperate to form screen 71.

Combustion air and fuel are supplied through the burner ports to the lower portion of compartments 27A, 27B. The resulting heating gases flow upwardly through the compartments and over the radiant heat absorbing portion of super-heater 30 to the gas inlet of gas pass 17; then flow through gas pass 17 while successively contacting the convection heat absorbing portion of superheater 30 and reheater 31, and then divide into parallel flow streams, with one stream passing through gas pass 32 in contact with a portion of primary superheater 36 and economizer 38, and the other stream flowing through gas pass 33 in contact with reheater 37 and the remainder of superheater 36 and economizer 38, and then the parallel flow gas streams combine for flow through gas pass 26 in contact with economizer 41.

While in accordance with the provisions of the statutes we have illustrated and described herein the best form and mode of operation of the invention now known to us, 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 our claims, and that certain features of our invention may sometimes be used to advantage without a corresponding use of other features.

We claim:

1. In a forced circulation fluid heating unit, upright walls forming a furnace for the flow of heating gases, burner means supplying high temperature heating gases to said furnace, said walls including lower and upper tube panels respectively cooperating to form lower and upper fluid heating passes and providing flow of fluid through the panels only in an upward direction, means for passing vaporizable fluid in parallel flow relation to the tube panels of the lower fluid heating pass, means for mixing the fluid outflow of the tube panels of the lower fluid heating pass of a pair of said walls and for passing such mixed fluid outflow only to the tube panels of the upper fluid heating pass of another of said walls, means for mixing the fluid outflow of the tube panels of the lower fluid heating pass of said other wall and for passing such mixed fluid outflow only to the tube panels of the upper fluid heating pass of said pair of walls, and means for mixing the fluid outflow of the tube panels of the lower fluid heating pass of still another of said walls and for passing such mixed fluid outflow only to the tube panels of the upper fluid heating pass of the corresponding wall.

2. In a forced circulation fluid heating unit, upright walls forming a furnace for the flow of heating gases, burner means supplying high temperature heating gases to said furnace, said walls including lower, intermediate and upper tube panels respectively cooperating to form first, second, and third fluid heating passes and providing flow of fluid through the panels only in upward direction, means for passing vaporizable fluid in parallel flow relation to the tube panels of the first fluid heating pass, means for mixing the fluid outflow of the tube panels of each wall of the first fluid heating pass and for passing such mixed fluid outflow only to the tube panels of the corresponding wall of the second fluid heating pass, means for mixing and passing all the fluid outflow of the tube panels of the second fluid heating pass of a pair of said walls and for passing such mixed fluid outflow only to the tube panels of the third fluid heating pass of another of said walls, means for mixing the fluid outflow of the tube panels of the second fluid heating pass of said other wall and for passing such mixed fluid outflow only to the tube panels of the third fluid heating pass of said pair of walls, and means for mixing the fluid outflow of the tube panels of the second fluid heating pass of still another of said walls and for passing such mixed fluid outflow only to the tube panels of the third fluid heating pass of the corresponding wall.

3. In a forced circulation fluid heating unit, first, second, third and fourth walls forming a furnace for the flow of heating gases, burner means supplying high temperature heating gases to said furnace, said walls including lower, intermediate and upper tube panels respectively cooperating to form first, second, and third fluid heating passes and providing continuous upflow of fluid through the panels, means for passing vaporizable fluid in parallel flow relation to the tube panels of the first fluid heating pass, means for mixing the fluid outflow of the tube panels of each wall of the first fluid heating pass and for passing such mixed fluid outflow only to the tube panels of the corresponding wall of the second fluid heating pass, means for mixing the fluid outflow of the tube panels of the first and second walls of the second fluid heating pass and for passing such mixed fluid outflow only to the tube panels of the third wall of the third fluid heating pass, means for mixing the fluid outflow of the tube panels of the third wall of the second fluid heating pass and for passing such mixed fluid outflow only to the tube panels of the first and second walls of the third fluid heating pass, and means for mixing the fluid outflow of the tube panels of the fourth wall of the second fluid heating pass and for passing such mixed fluid outflow only to the tube panels of the corresponding wall of the third fluid heating pass.

4. In a forced circulation fluid heating unit, first, second, third and fourth walls forming a furnace for the flow of heating gases, burner means supplying high temperature heating gases to said furnace, each of said walls including lower, intermediate and upper tube panels respectively cooperating to form first, second, and third fluid heating passes and providing flow of fluid through the panels only in an upward direction, means for passing vaporizable fluid in parallel flow relation to the tube panels of the first fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of each wall of the first fluid heating pass to only the tube panels of the corresponding wall of the second fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the first and second walls of the second fluid heating pass to only the tube panels of the third wall of the third fluid heating pass, means for mixing and passing all the fluid outflow of the tube panels of the third wall of the second fluid heating pass to only the tube panels of the first and second walls of the third fluid heating pass, and means for mixing and passing all the fluid outflow of the tube panels of the fourth wall of the second fluid heating pass to only the tube panels of the corresponding wall of the third fluid heating pass.

5. In a forced circulation fluid heating unit, upright walls forming a furnace for the flow of heating gases, burner means supplying high temperature heating gases to said furnace, said walls including lower, intermediate and upper tube panels respectively cooperating to form first, second and third fluid heating passes and providing continuous upflow of fluid through the panels, means for passing vaporizable fluid in parallel flow relation to the tube panels of the first fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the first fluid heating pass to the tube panels of the second fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of a pair of said walls to only the tube panels of the third fluid heating pass of another of said walls, means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of said other wall to only the tube panels of the third fluid heating pass of said pair of walls, and means for mixing and passing the fluid out-

flow of the tube panels of the second fluid heating pass of still another of said walls to only the tube panels of the third fluid heating pass of the corresponding wall.

6. In a forced circulation fluid heating unit, upright walls forming a furnace for the flow of heating gases, burner means supplying high temperature heating gases to said furnace, said walls including lower, intermediate and upper tube panels respectively cooperating to form first, second and third fluid heating passes and providing continuous upflow of fluid through the panels, means for passing vaporizable fluid in parallel flow relation to the tube panels of the first fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the first fluid heating pass to the tube panels of the second fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of a pair of said walls to the tube panels of the third fluid heating pass of another of said walls, and means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of said other wall to the tube panels of the third fluid heating pass of said pair of walls.

7. In a forced circulation vapor generator, upright walls forming a furnace for the flow of heating gases, burner means supplying high temperature heating gases to said furnace, said walls including lower, intermediate and upper tube panels respectively cooperating to form vertically spaced first, second and third fluid heating passes and providing flow of fluid through the panels only in an upward direction, means for passing vaporizable fluid in parallel flow relation to the tube panels of the first fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the first fluid heating pass to the tube panels of the second fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of a pair of said walls to the tube panels of the third fluid heating pass of another of said walls, means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of said other wall to the tube panels of the third fluid heating pass of said pair of walls, and means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of still another of said walls to the tube panels of the third fluid heating pass of the corresponding wall.

8. In a forced circulation fluid heating unit, upright walls forming a furnace for the flow of heating gases, burner means supplying high temperature heating gases to said furnace, said walls including lower, intermediate and upper tube panels respectively cooperating to form first, second and third fluid heating passes and providing continuous upflow of fluid through the panels, means for passing vaporizable fluid in parallel flow relation to the tube panels of the first fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the first fluid heating pass to the tube panels of the second fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of a pair of said walls to the tube panels of the third fluid heating pass of another of said walls, means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of said other wall to the tube panels of the third fluid heating pass of said pair of walls, and means for mixing and passing the fluid outflow of the tube panels of the second fluid heating pass of still another of said walls to only the tube panels of the third fluid heating pass of the corresponding wall.

9. In a forced circulation fluid heating unit, first, second, third, and fourth walls forming a furnace for the flow of heating gases, burner means supplying high temperature heating gases to said furnace, each of said walls including lower, intermediate and upper tube panels respectively cooperating to form vertically spaced first, second, and third fluid heating passes and providing flow of fluid through the panels only in an upward direction, the panels of each wall being rigidly united and comprising a row of rigidly united parallel flow tubes, means for passing vaporizable fluid in parallel flow relation to the tube panels of the first fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of each wall of the first fluid heating pass to only the tube panels of the corresponding wall of the second fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the first and second walls of the second fluid heating pass to only the tube panels of the third wall of the third fluid heating pass, means for mixing and passing the fluid outflow of the tube panels of the third wall of the second fluid heating pass to only the tube panels of the first and second walls of the third fluid heating pass, and means for mixing and passing the fluid outflow of the tube panels of the fourth wall of the second fluid heating pass to only the tube panels of the corresponding wall of the third fluid heating pass.

10. In a forced circulation fluid heating unit, upright front, rear and side walls forming a furnace for flow of heating gases, burner means supplying high temperature heating gases to said furnace, all of said walls including lower and upper tube panels respectively cooperating to form lower and upper fluid heating passes and providing flow through the panels only in an upward direction, panels of each fluid heating pass being rigidly united and arranged in parallel flow relation and comprising a row of rigidly united parallel flow tubes, means for passing a vaporizable fluid in parallel flow relation to the tube panels of the lower fluid heating pass, and means for mixing the fluid outflow of the tube panels of each wall of the lower fluid heating pass and for passing such mixed fluid outflow in parallel flow relation only to the tube panels of the corresponding wall of the upper fluid heating pass.

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