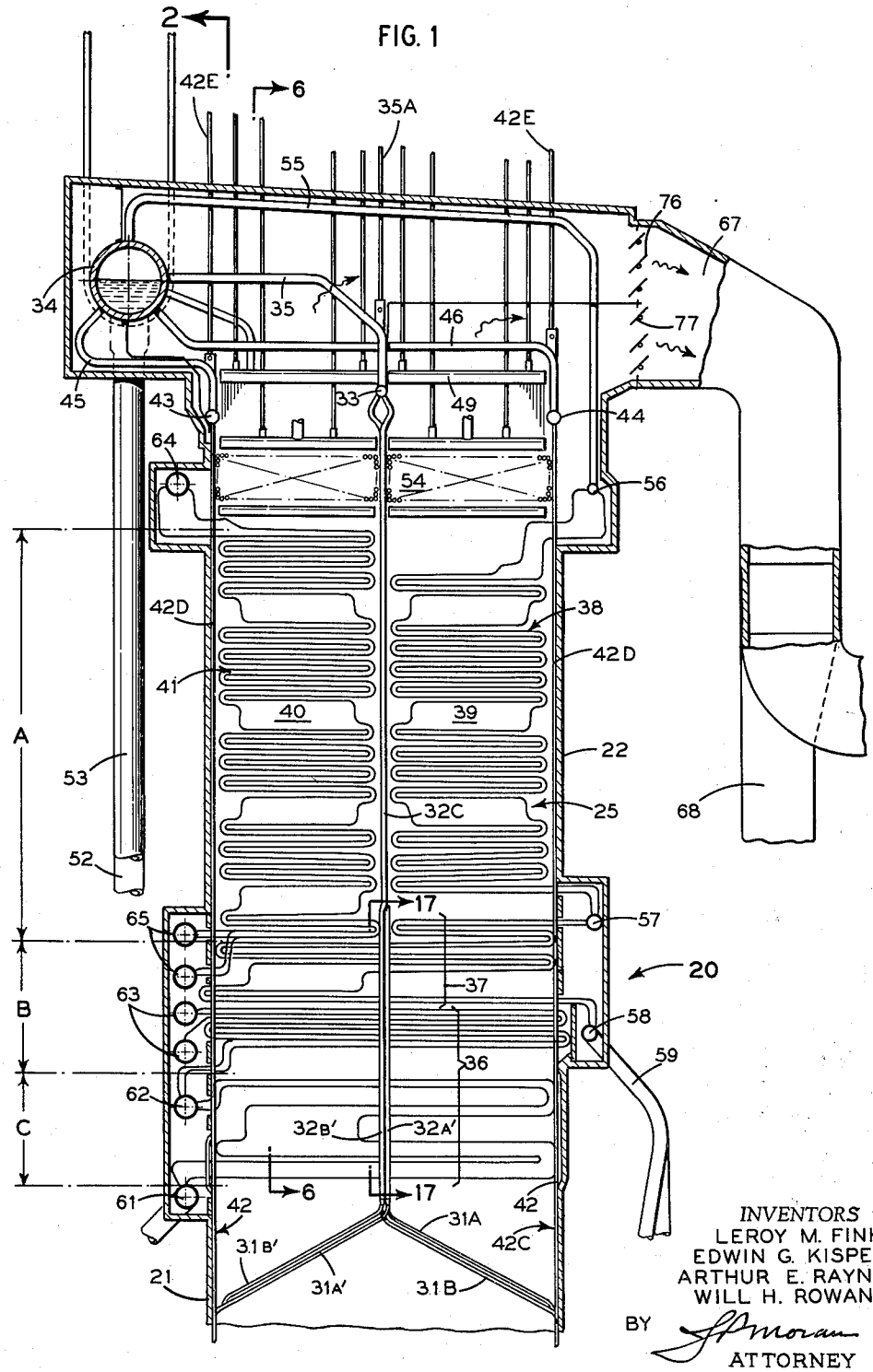
Oct. 10, 1961 L. M. FINK ET AL 3,003,480

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FIG. 1



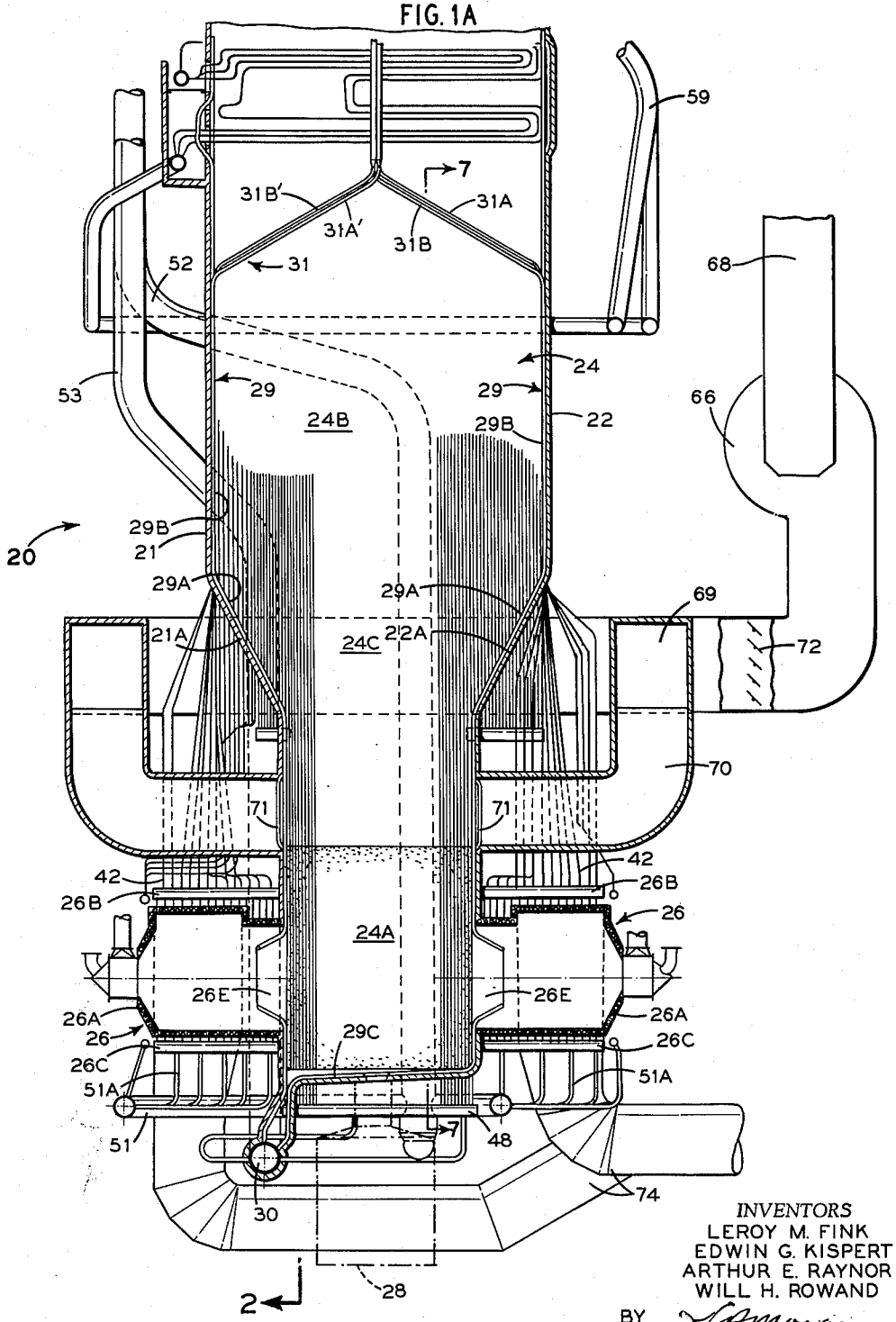
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FIG. 1A



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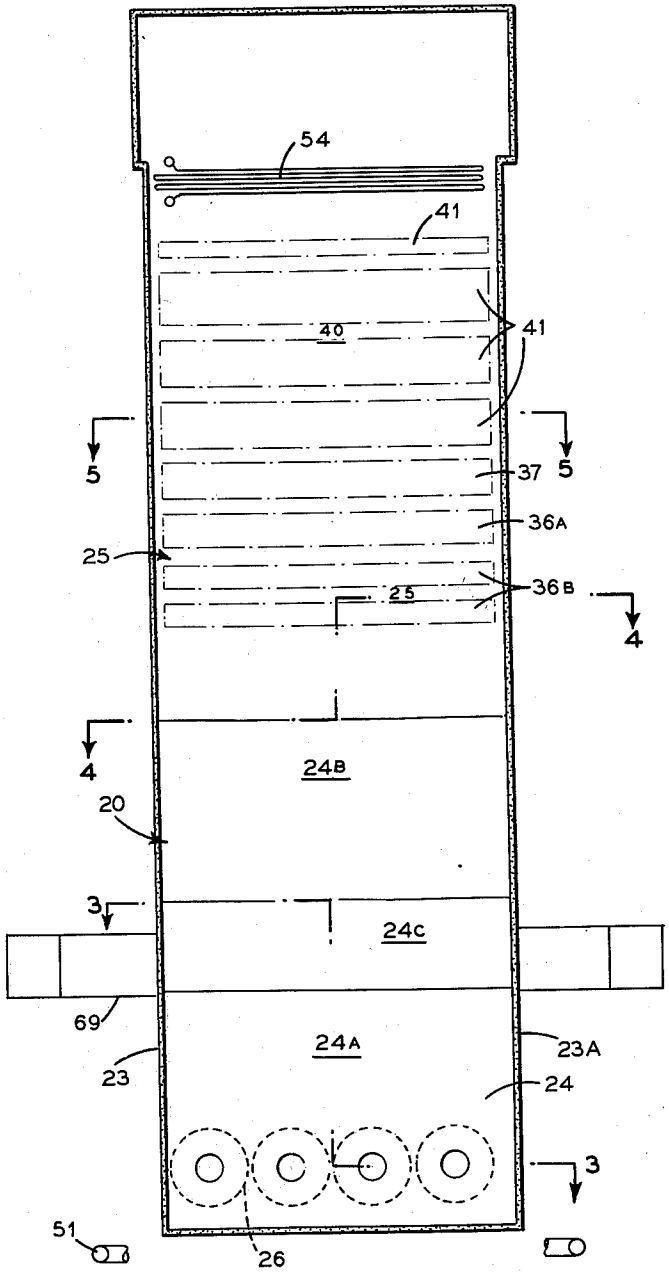
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FIG. 2



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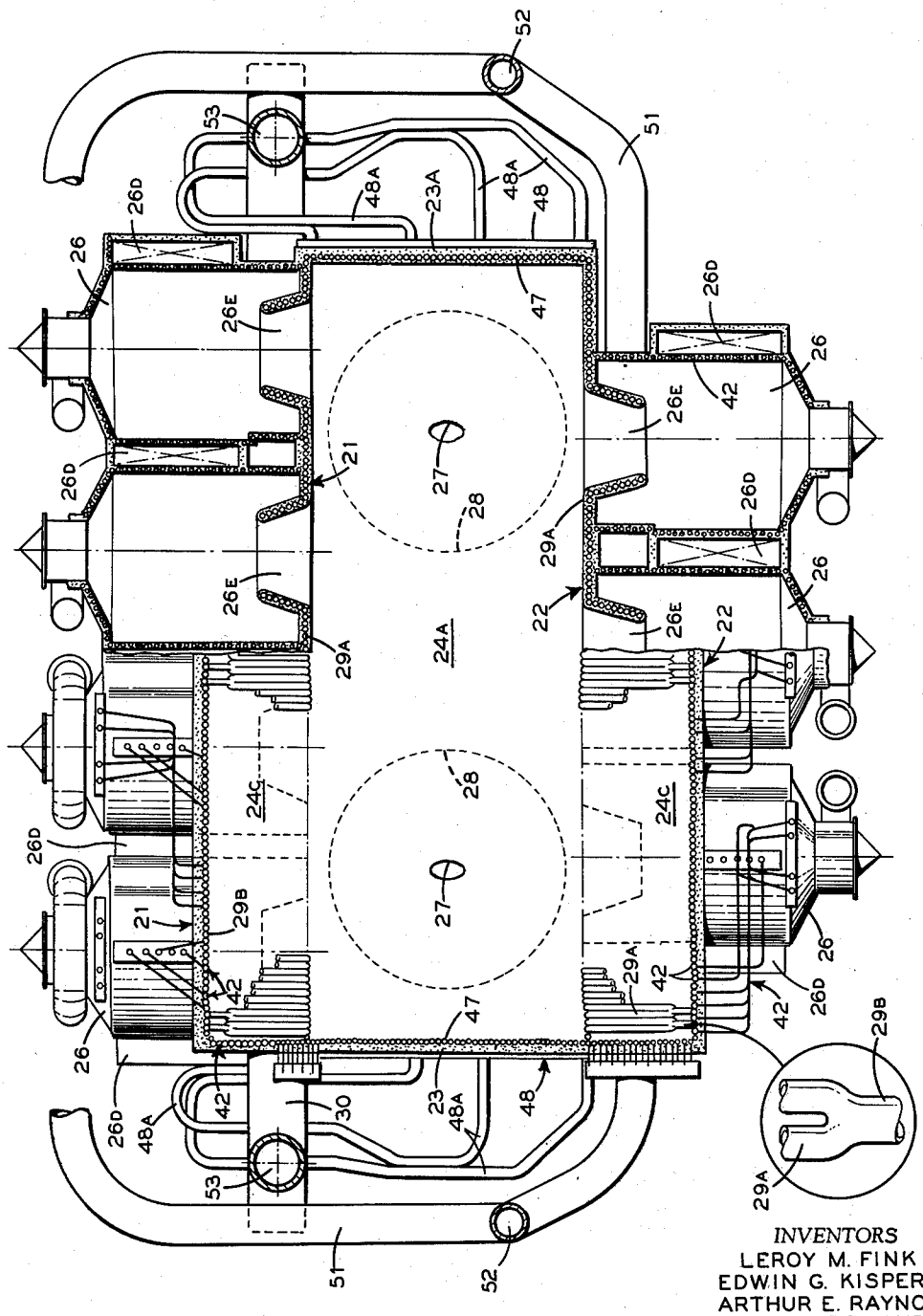
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FIG. 3



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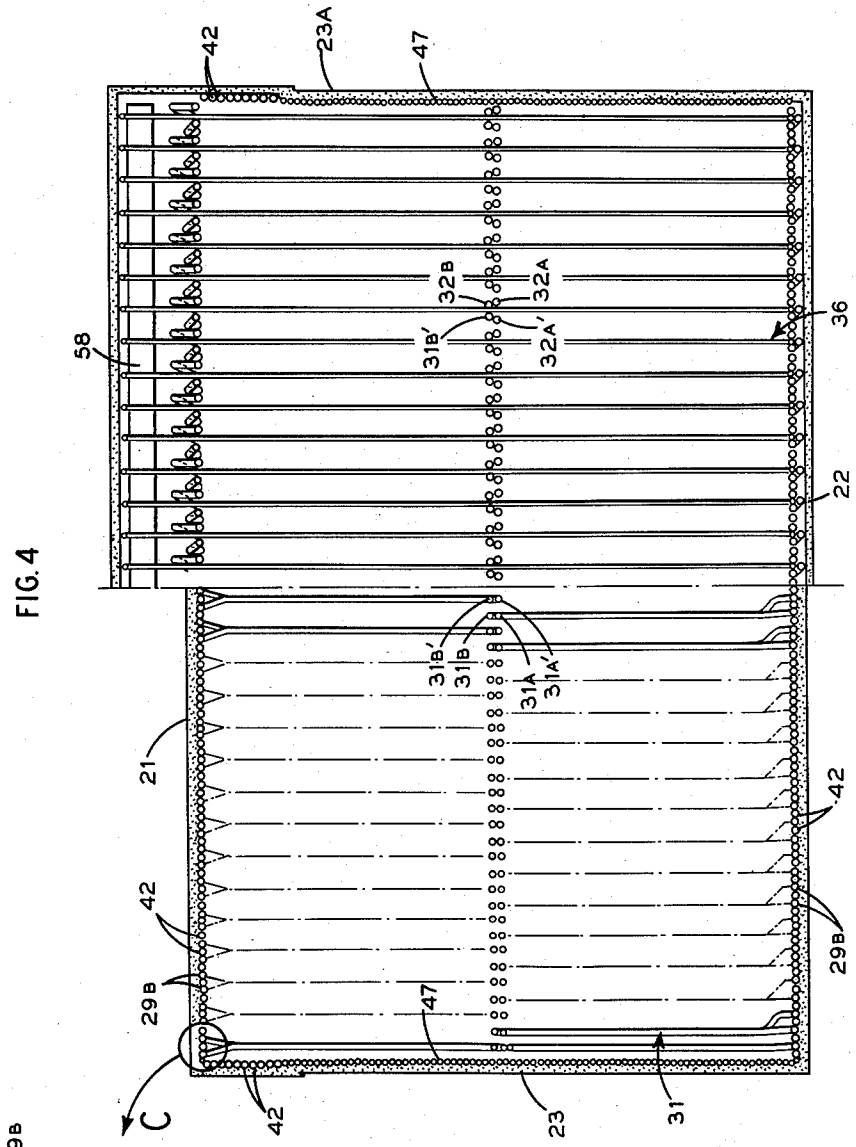


FIG. 4

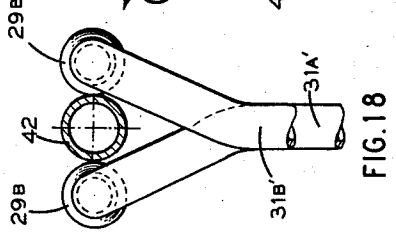


FIG. 18

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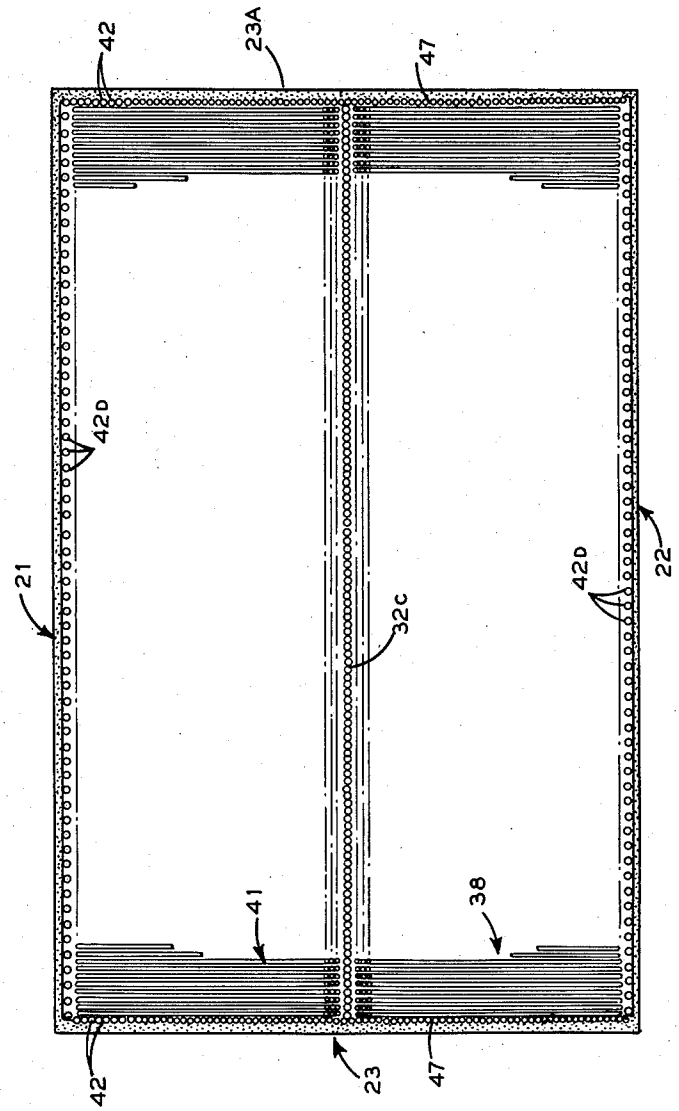
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FIG. 5



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FIG. 6

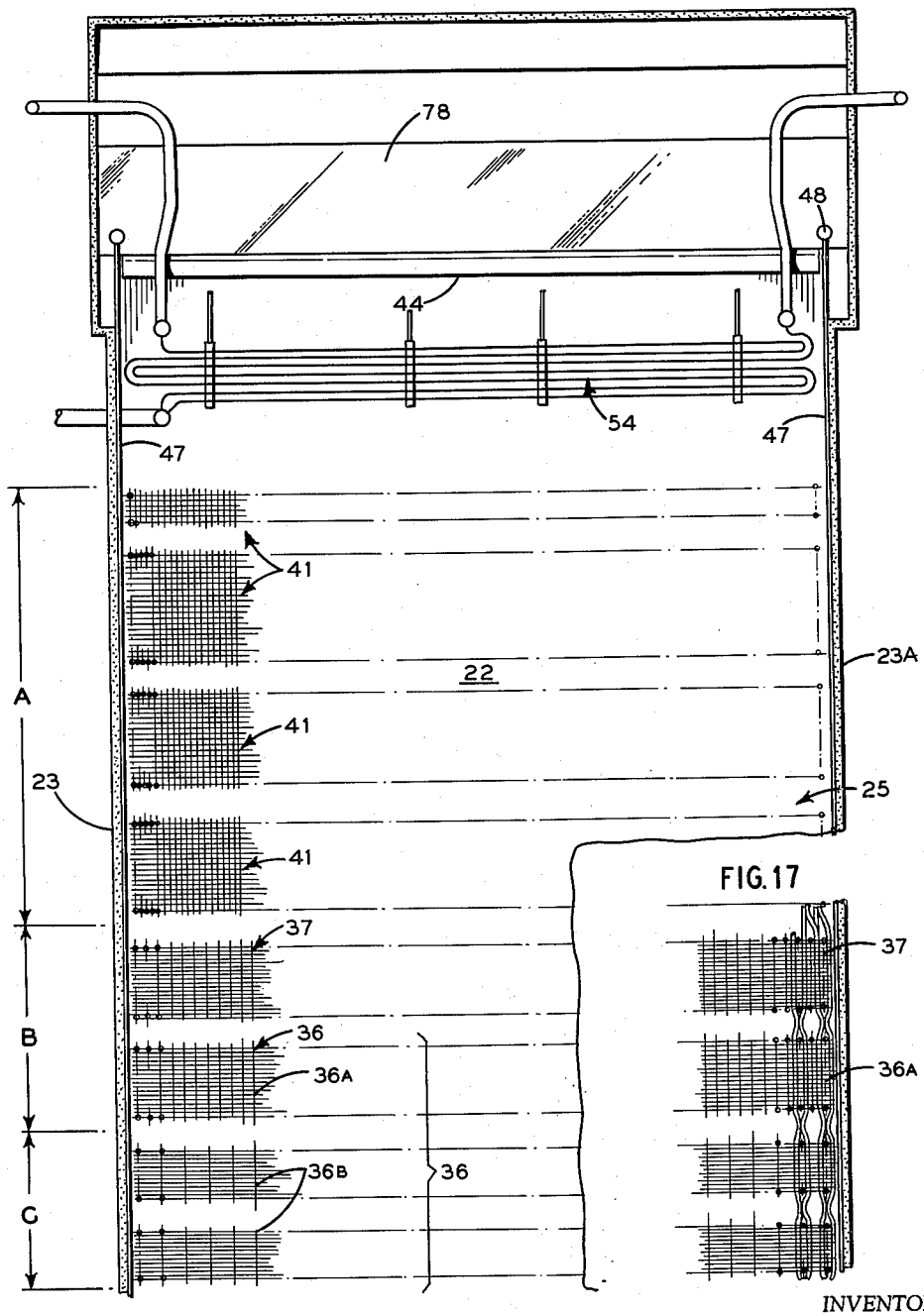


FIG. 17

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FIG. 10

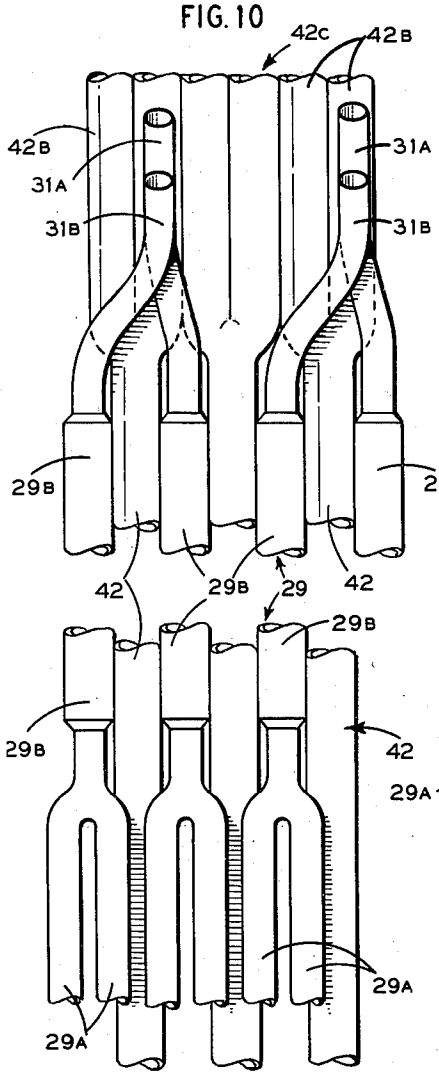


FIG. 9

FIG. 8

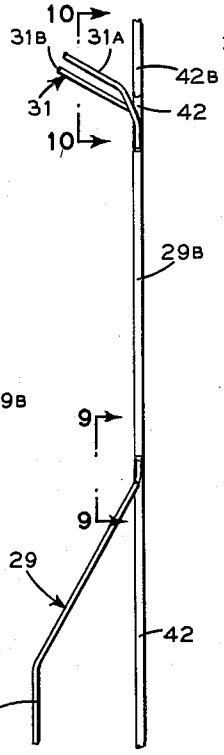
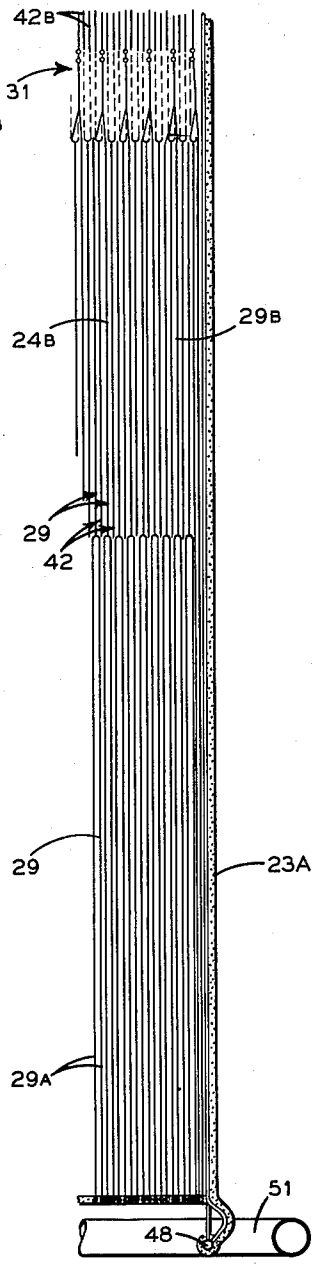


FIG. 7



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FIG. 12

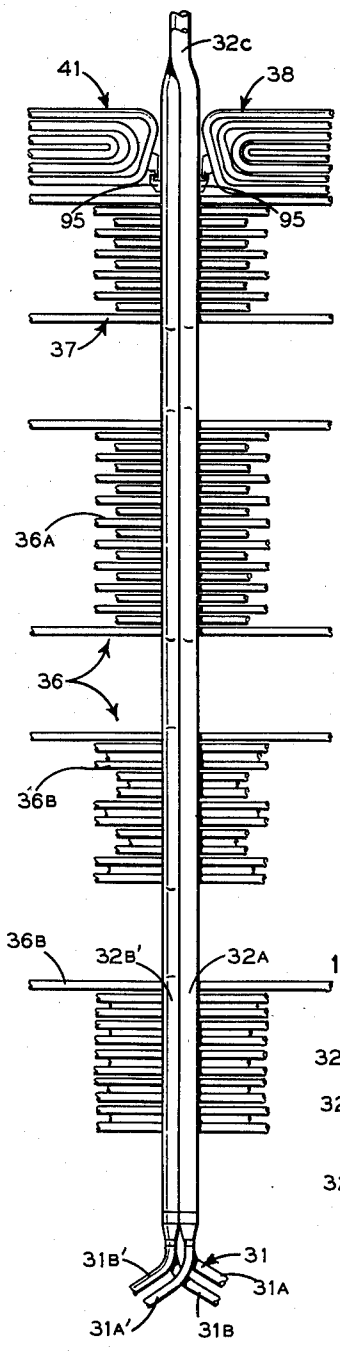


FIG. 16

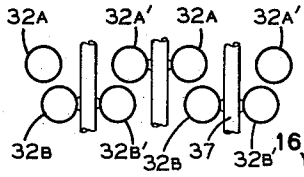


FIG. 13

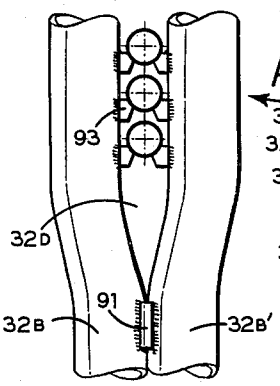


FIG. 14

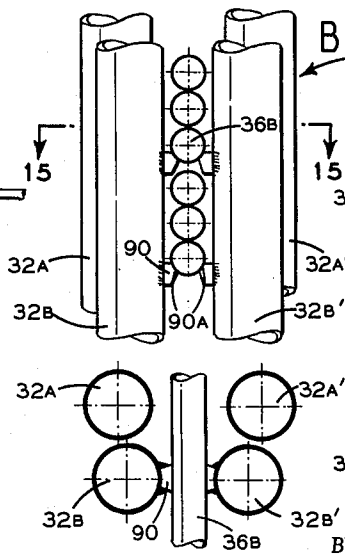
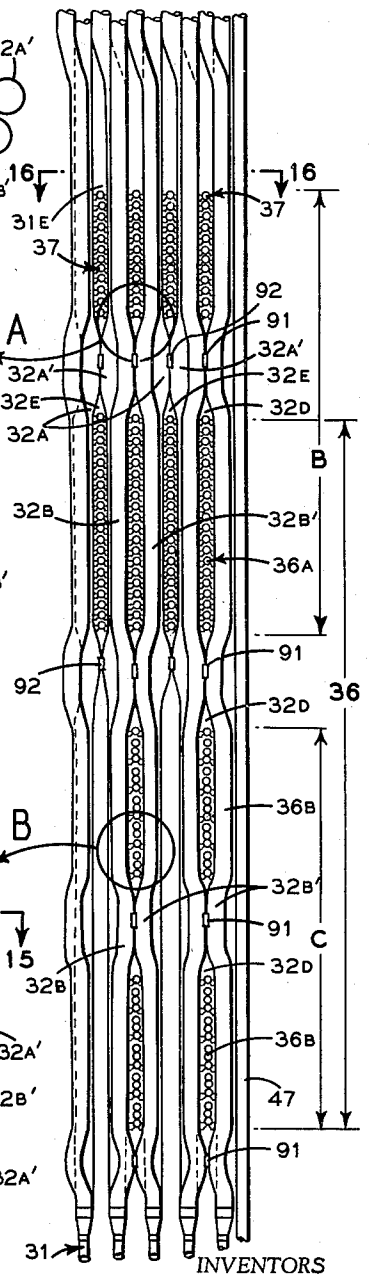


FIG. 15

FIG. 11



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United States Patent Office 3,003,480 Patented Oct. 10, 1961

3,003,480

VAPOR GENERATOR

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Filed June 19, 1957, Ser. No. 666,657
10 Claims. (Cl. 122—235)

This invention relates to the construction and operation of a vapor generating and superheating unit and more partciularly to a natural circulation high capacity, high pressure steam generating unit for simultaneously superheating and reheating steam to high temperatures by the burning of a slag forming fuel in cyclone type furnaces.

Modern high capacity, high pressure steam generating units are customarily designed to operate with substantially constant steam temperature and pressure conditions over a range of steam loadings. Units of this type are further characterized by a major portion of the total heat absorbing surfaces being utilized as steam heating surfaces and substantially all of the remaining surface being radiant heat absorbing steam generating tubes. When these units are fired by a plurality of cyclone furnaces, of the general type disclosed in U.S. Patent 2,594,312 for example, the load range characteristic may be achieved by reducing the firing rate of the cyclone furnaces or by selectively removing individual cyclone furnaces from service as the steam demand is reduced, resulting in changes in the furnace heat transmission pattern and in the associated thermo-syphonic head relationship of the natural circulation system serving the steam generating tubes. As a consequence, undesirable changes may occur in the fluid flow rates prevailing within the circulating system of the unit.

To avoid such undesirable fluid flow conditions, an object of this invention is to provide in a natural circulation vapor generating and superheating unit of the character described an arrangement comprising a plurality of independent circulation systems to assure optimum fluid flow conditions within the unit over the customary range of steam loadings and heat absorption requirements imposed thereon.

Another object is to provide an arrangement whereby the riser or discharge tubes in communication with and receiving fluid from the steam generating tubes defining the walls of the cyclone furnaces are extended upwardly into aligned relationship with other steam generating tubes lining the front and rear walls of an associated radiation chamber so as to be in heat absorbing relation to the combustion gases flowing therethrough, the cyclone furnace riser tubes and the other steam generating tubes being arranged as separate fluid flow circuits from and to an elevated steam and water separating drum.

Another object of the invention resides in a novel setting arrangement, adapted to be fired by opposed cyclone furnaces burning a slag forming fuel, comprising vertically disposed fluid cooled walls defining a relatively small radiation section and having a minimum amount of heat absorbing surfaces which in conjunction with gas tempering means reduces the temperature of the gases exiting said radiation section to a point whereby entrained slag particles in the combustion gases are substantially solidified prior to entering a vertically superposed convection section. The latter is divided by a division wall of vapor generating tubes into a pair of convection gas passes in which there are disposed vapor heating tubes, the division wall being formed of vertical extensions of a tube screen traversing the setting adjacent the gas exit

of the radiation section to separate the latter from the convection heating section.

Another object of this invention is to provide an arrangement whereby the tubes receiving fluid from the cyclone furnace walls function in cooperation with other steam generating tubes to provide similarly heated fluid carrying support members for sustaining a major portion of the loading of the unit which is top supported from upper structural support members.

Still another object of the invention is to provide a novel means for supporting horizontally disposed vapor heating tubes extending across the width of the unit and positioned between adjacent pairs of upwardly extending support tubes which define parallel convection heating gas passes.

Succinctly stated, the invention resides in distinctively combining portions of a plurality of separate, natural circulation systems in heat absorbing relationship as portions of boundary walls of a steam generating unit and utilizing a combination of other portions of said circulation systems, absorbing heat in other zones, which latter portions at the same time function as load carrying support members for other heat absorbing components.

The various features of novelty which characterize our invention are pointed out with particularlity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described preferred embodiments of the invention.

FIGURE 1 is a sectional side elevation of the upper portion of the steam generating, superheating and reheating unit according to this invention.

FIGURE 1A is a sectional side elevation of the lower portion of the unit.

FIGURE 2 is a diagrammatic sectional view taken along line 2—2 of FIGS. 1 and 1A.

FIGURE 3 is a composite plan section taken along line 3—3 of FIG. 2.

FIGURE 4 is a composite plan section taken along line 4—4 of FIG. 2.

FIGURE 5 is a plan section along line 5—5 of FIG. 2.

FIGURE 6 is a fragmentary vertical section taken along line 6—6 of FIG. 1.

FIGURE 7 is a fragmentary vertical section taken substantially along line 7—7 of FIG. 1A at a corner of the setting.

FIGURE 8 is a fragmentary side view of FIG. 7.

FIGURE 9 is an enlarged detail view taken along line 9—9 of FIG. 8.

FIGURE 10 is an enlarged detail view taken along line 10—10 of FIG. 8.

FIGURE 11 is an enlarged detailed view of FIGURE 17 illustrating the secondary superheater supporting means.

FIGURE 12 is a side view of FIG. 11.

FIGURE 13 is an enlarged view of Detail A of FIGURE 11.

FIGURE 14 is an enlarged view of Detail B of FIGURE 11.

FIGURE 15 is a plan view taken along line 15—15 of FIGURE 14.

FIGURE 16 is a plan view taken along line 16—16 of FIGURE 11.

FIGURE 17 is a fragmentary section taken along line 17—17 of FIGURE 1.

FIGURE 18 is an enlarged view of Detail C in FIGURE 4.

Illustrative of this invention, the drawings show a natural circulation steam generating and superheating

unit, having a maximum continuous generating capacity of approximately 2,100,000 lbs. per hour operating at a pressure of 2450 p.s.i. and a final steam temperature of approximately 1053° F. at the superheater outlet. The unit also includes a steam reheater capable of reheating low pressure steam returned from a turbine to a temperature of the order of 1053° F.

FIGURES 1, 1A and 2 show a vertically extending setting 20 having front, rear and side walls 21, 22, 23, and 23A respectively, defining a radiation section 24, and a superposed convection heat absorbing section 25. The radiation section 24 includes a lower radiation chamber 24A of relatively small volume defined by the lower portions of the above mentioned front, rear and side walls, an enlarged superposed upper radiation chamber 24B, and a connecting transition zone 24C disposed therebetween, the latter being formed by upwardly diverging front and rear wall portions 21A and 22A.

A plurality of cyclone furnaces 26, of the general type disclosed in U.S. Patent 2,594,312, adapted to be independently fired by coarsely pulverized or granulated coal, are arranged for opposed firing and each separately discharges hot gaseous products of combustion and molten slag into the lower chamber 24A. Each of the cyclone furnaces 26 is substantially circular in cross-section, having the barrel portion thereof defined by steam generating tubes 26A which connect to upper and lower headers 26B and 26C. Riser or discharge tubes 42 connect the upper headers 26B of the respective cyclone furnaces to upper front and rear wall headers 43 and 44, which in turn are connected to the elevated steam and water drum 34 by riser tubes 45 and 46, the riser tubes 42 extending upwardly into the walls of the setting and in cooperation with front, rear, side and division wall tubes to provide the steam generating components of the unit as will be hereinafter described.

As seen in FIGURE 3, a group of four horizontally extending cyclone furnaces are laterally arranged to fire through the front wall 21, while a group of three cyclone furnaces are disposed to fire through the opposite or rear wall 22. When viewing the front wall cyclone furnaces from outside of the unit the secondary air inlets 26D of the two cyclone furnaces nearer to side wall 23A are so positioned as to cause the whirling gases to discharge from the throats 26E in a clockwise direction; the air inlets 26D of the cyclone furnaces nearer to side wall 23 are arranged in opposite hand so the whirling gases therefrom are discharged in a counter-clockwise direction. When viewing the rear wall cyclone furnaces from outside of the unit, the products of combustion of the cyclone furnace adjacent to wall 23 are discharged in a clockwise direction while those from the two cyclone furnaces next to wall 23A leave in a counter-clockwise direction. Thus the rotation of gases issuing from both the front and rear wall cyclone furnaces nearer sidewall 23 is in the same direction. A similar relationship exits as regards the direction of rotation of the gases issuing from the front and rear cyclone furnaces nearer sidewall 23A.

With the cyclone furnaces disposed in the opposite walls laterally offset or staggered with respect to each other, as shown in FIGURE 3, opportunity is afforded for the effluent gases to become thoroughly mixed, i.e. uniformly distributed across the cross-sectional area of the unit. More particularly, the low pressure vortex zone, centrally positioned in the one gas stream, is subjected to penetration by the whirling stream of high velocity gases issuing from the cyclone furnaces located in the opposite side of the unit. The interaction of these gas streams promotes uniform gas distribution and more complete agglutination of molten slag particles present therein, causing the slag to fall to the bottom of the lower radiation chamber. Two spaced slag discharge openings 27 associated with slag collecting tanks 28 are provided at the bottom of chamber 24A.

According to this invention the first natural circulation system comprises steam generating tubes 29, see FIGS. 1, 1A, and 10, extending between a lower header 30 and an upper division wall header 33. These tubes extend upwardly from header 30 to line the front wall 21 of the lower chamber 24A and outwardly along wall 21A of the transition zone 24C, preferably as 3¼ in. O.D. tube segments 29A spaced on 4½ in. centers. At the upper boundary of the transition zone 24C adjacent pairs of the 3¼ in. O.D. tubes 29A are connected by an inverted Y fitting to a single enlarged diameter tube segment 29B which extends upwardly in the front wall 21 of the upper chamber 24B as shown in FIGS. 1A, 3, 7, 9 and 10. In this zone tube segments 29B comprise a 4¼ in. O.D. tube spaced on 9 in. centers, FIGS. 7 to 10.

Tubes 29 lining the rear wall 22 of the lower and upper chambers 24A, 24B are similarly arranged except that the 3¼ in. O.D. tube portion 29A constitute a continuation of the bottom wall or floor tubes 29C which are connected to lower header 30. As shown in FIG. 1A, the floor tubes 29C and the lower portions of the front and rear wall tubes lining the lower portion of radiation chamber 24A are covered with refractory.

Separating the radiation chamber 24 from the superposed convection section 25 is a screen 31, the screen being formed of inclined, inwardly bent extensions of tube segments 29B. Referring to FIGS. 8, 10, and 18, it will be seen that the screen tubes 31 have an outside diameter which is less than that of tube sections 29B from which they extend. As shown the tube segments extending inwardly from wall 21 and 22 are laterally bent and paired to form a screen of superposed tube segments 31A, 31B and 31A', 31B' respectively. Centrally between the front and rear walls screen tube segments 31A, 31B and 31A', 31B' continue vertically upwardly to provide a wall structure, the upper portion of which divides the convection pass into two parallel gas passes 39 and 40. The vertical extensions comprising tube segments 32A, 32B and 32A', 32B', respectively have a larger outside diameter than the screen segments. Tube segments 32A, 32B, 32A', 32B' extend upwardly to connect into the division wall header 33, the latter in turn being connected to the steam and water drum 34 by a plurality of riser tubes 35, the division wall being supported by hangers 35A to external steel supporting structure (not shown). As will be hereinafter described tube segments 32A, 32B; 32A', 32B' are further utilized as fluid cooled support members for the superheater and reheater tubes.

The lower portions of adjacent pairs of tube segments 32A, 32B; 32A', 32B' have vertically spaced, laterally bent portions to form spaces 32D and 32E to accommodate the transversely extending, horizontal disposed secondary superheater tubes 36 as well as the transversely extending portion 37 of the primary superheater tubes 38, as shown in FIGS. 11 to 16. Beyond superheater tubes 37 the upper portion of tube segments 32A, 32B; 32A', 32B' are brought into vertical alignment so as to be in contiguous, tangent alignment to form an imperforate division wall 32C dividing the upper heat absorbing section 25 into parallel gas passes 39 and 40 with a primary superheater 38 disposed in one pass and a reheater 41 disposed in the other.

According to this invention, the second natural circulation system comprises the cyclone furnace wall cooling tubes 26A and the riser tubes 42, the latter extending upwardly from respective headers 26B externally of the setting until they reach the lower end of the upper radiation chamber 24B. At this elevation tubes 42 come into contiguous, alternately spaced, alignment with the front and rear wall tube segments 29B lining the upper radiation chamber 24B, as shown in FIGURES 4, 7 and 9, and thus are in heat absorbing relationship with the hot combustion gases flowing upwardly through radiation chamber 24B. It will be seen that all of the cyclone furnace riser tubes 42 are exposed to gaseous radiant heat emission whenever the steam generator is in operation,

even though some of the cyclone furnaces are not being fired at that particular time. Heat absorption in the riser tubes 42 associated with each operating cyclone furnace augments the thermo-syphonic head that would exist if the heat absorption were confined to the cyclone furnace wall tubes alone. In the event anyone of the cyclone furnaces is idle, the respective riser tubes 42 thereof, in heat absorbing relationship with the combustion gases induces a flow therein by virtue of the thermo-syphonic head produced in the heated sections of the riser tubes.

The cyclone furnace riser tubes 42 continue upwardly above the screen 31 and immediately therebeyond are bifurcated, becoming tube sections 42B, as shown in FIGURES 8 and 10, and form a tangent tube wall portion 42C along the front and rear wall of the convection section 25 in the vicinity of the secondary superheater section 36. Beyond the secondary superheater section 36 adjacent pairs of riser tubes 42B are connected to form a wall portion of spaced tube section 42D, as shown in FIG. 5, which continues vertically upward along walls 21 and 22 adjacent the reheater 41 and primary superheater 38 and terminate in the upper front and rear wall headers 43 and 44, respectively. Riser tubes 45 and 46 connect the headers 43 and 44 to the steam and water drum 34. The riser tubes 42 serve as support members carrying the weight of the cyclone furnaces as well as a portion of the weight of the setting, and transmitting the load by hangers 42E to external steel work (not shown) at the top of the unit.

The side walls 23 and 23A of the setting, defining the sides of the convection gas passes 39 and 40 and the radiation section 24, extend in a single vertical plane between the upper and lower side wall headers 48 and 49 respectively, each of the side walls being lined with vapor generating tubes 47 connecting into said headers 48 and 49. The lower header 48 in turn is connected to header 30 by conduits 48A to become part of said first mentioned circulatory system.

As shown in FIGS. 3, 4 and 5, a portion of the discharge tubes 42 of the front wall cyclone furnaces adjacent the side walls 23 and 23A are accommodated in the adjacent side wall and form a distinct section thereof. The lower portion of the tubes in the side walls 23, 23A of the lower radiation chamber 24A are covered with refractory as are the front and rear wall tubes 29A in that zone.

A significant feature of this invention resides in the provision whereby the steam generating tubes 29 comprising the front, rear, division walls and tubes 47 of the side walls 23, 23A; and the cyclone furnace wall tubes 26A and riser tubes 42 are connected into separate and distinct supply and riser circuits. This is accomplished by a header 51 circumscribing the lower portion of the setting to form the source of water supply for the discharge tubes 42 only, and header 30 supplies the water to the wall generating tube 29 and 47. Headers 30 and 51, respectively, are separately connected with the steam and the water drum 34 by a pair of oppositely disposed downcomers. As shown in FIGS. 1, 1A and 3, the downcomers 52, 53 are longitudinally spaced along the drum, the outermost pair of downcomers 52, connecting into the ends of the drum, communicate with ring header 51 and the innermost pair 53 connects the drum to the header 30. Supply tubes 51A interconnect header 51 and the cyclone furnace headers 26C. With this arrangement it has been discovered that more positive control of the cyclone circuit is had; that is the optimum fluid flow rates in the circulating system are assured throughout the operating load range of the unit, the fluid flow characteristics of the cyclone circuit becoming quickly stabilized when changes in the cyclone furnace firing rates occur.

An economizer 54 having a portion of its heat absorbing surfaces disposed in each of the two passes 39 and 40, supplies feed water to the steam drum 34. According to this invention the heat absorbing section 25 between the economizer 54 and the screen 31 comprises zones A, B and C, each zone having disposed therein a bank of steam heating tubes. Each bank comprises a plurality of laterally spaced vertical tube rows formed of nested or return bend tubes. According to this invention the lateral, or transverse, spacing between the tube rows disposed in each of said zones is progressively decreased in the ascending order of said tube banks.

For example, in zone A there is disposed a primary superheater 38 and a reheater 41, the former being located in the convection pass 39 and the latter in pass 40. In the illustrated form of the invention, the tube rows of the primary superheater 38 and the reheater 41 are spaced on 4½ in. centers, the reheater tubes being of a larger diameter than the tubes of the superheater bank 38.

In zone B there is disposed an intermediate tube bank including a portion 37 of the primary superheater 38 and a subjacent section 36A of the secondary superheater. In this zone the tube bank comprises horizontally extending, return bend tubes transversing the width of the setting immediately upstream from the convection pass inlets, the tubes extending through spaces 32D and 32C formed by the lateral offsets between adjacent pairs of tubes 32A, 32A'; 32B, 32B', see FIGS. 11, 12 and 16. As shown in FIG. 6, the lateral spacing between the transversely extending tube rows in the intermediate tube bank in zone B, is greater than the lateral spacing of the tubes in zone A. In the illustrated form of the invention the rows of the intermediate tube bank are spaced on 9 in. centers.

In zone C, there is disposed the lowermost bank of vapor heating tubes. This bank includes the second portion 36B of the secondary superheater. The tubes comprising this bank likewise extend transversely of the setting in which the return bends thereof form tube rows that are spaced on 18 in. centers.

Referring to the drawings, FIGS. 11 through 16, the transversely extending superheater tubes 36 and 37, disposed in zones B and C, are supported intermediate their length on and between alternate adjacent pairs of tubes 32A, 32A'; 32B, 32B'. As the superheater tube rows 36B disposed in zone C are spaced on 18 in. centers, the adjacent paired tubes 32B, 32B' are provided with complementary supports in the form of cantilever brackets 90 extending inwardly between said tube pairs of supporting the superheater tubes 36B. In the illustrated form of the invention, as shown in FIGS. 11 and 14, tubes 36B are supported either singly or vertically in stacked groups by opposed brackets 90. Brackets 90 are provided with an arcuate seat portion 90A which engages the bottom portion of the lowermost tube of each of the groups of tubes or the singly supported tube. In the illustrated form the tubes are supported in groups of three with the odd tube singly supported. As the weight of the tubes is supported on brackets 90 and as the brackets are provided with an arcuate seat portion 90A, the thrust of the lateral weight component imposed thereon tends to displace the supporting tubes 32B, B' laterally. In order to overcome the tendency of lateral displacement of the support tubes 32B, 32B', the latter are tied together by a weld as shown at 91. In the illustrated embodiment this is formed by welding a round bar stock to and between the tubes at the bend thereof as shown in FIG. 13. Accordingly, tubes 32B, 32B' are paired transversely across the setting to support all of the tube rows making up the lowermost tube bank 36B, the corresponding tubes 32A, 32A' at this elevation comprising merely straight nonsupporting tube sections, see FIGS. 11, 14 and 15.

At the elevation of the intermediate superheater tube bank in zone B which include tubes 36A and 37, support tubes 32A, 32A' are inwardly bent above and below the tube rows 36A and 37, as are also the support tubes 32B, 32B'. As the rows of superheater tubes making up the intermediate tube bank are laterally spaced on 9 in. centers, tubes 36A and 37 are alternately supported on adjacent tube pairs 32B, 32B' and 32A, 32A'. See FIGS. 11 and 16.

In the illustrated embodiment the superheater tubes in the intermediate tube bank are individually supported on brackets 93 connected to adjacent tubes 32A, 32A' and 32B, 32B', brackets 93 being similar to brackets 90. Thus the weight of the horizontally extending tubes in zone B is equally distributed on all of the tubes 32, adjacent tube pairs supporting each row being welded together as indicated at 91 and 92 respectively in order to prevent the lateral displacement of tubes 32 as hereinbefore described. The superheater and reheater tubes 38 and 41 disposed in zone A are supported on and between the division wall tubes 32 and the cyclone riser tubes 42D of the front and rear wall. Conventional brackets 95 support the ends of elements 38 and 41 to their respective support tubes. See FIG. 12.

Accordingly, the vapor heating means of the instant invention are supported on similarly heated supporting members which are subjected to uniform linear displacement when heated. Consequently tilting of the horizontally disposed vapor heating tubes 36, 37, 38 and 41 is prevented.

Steam separated from the water in the steam and water drum 34 is directed through steam conduit 55 to the primary superheater inlet header 56. From header 56 the steam flows serially through connected tubes of the first primary superheater section 38 to an intermediate header 57 and then through a second section 37 of the primary superheater to the outlet header 58, the steam flow path through these tubes being in counterflow heat transfer relationship to the gas flow. From the primary superheater outlet header 58, steam is delivered through conduits 59 through a spray attemperator, (not shown) preferably of the type disclosed by Fletcher in U.S. Patent 2,550,683 to the inlet header 61 of the secondary superheater wherein the steam is heated to a final temperature of the order of 1050° F., the steam flow therethrough being in a parallel heat transfer relationship to the gas flow. Due to the difference in the lateral tube spacing of sections 36A and 36B, an intermediate header 62 is disposed therebetween, the steam flow being serial through section 36B, 36A respectively, thence to outlet headers 63.

Steam to be reheated is introduced into the inlet header 64 and flows through the reheater tubes 41 in counterflow heat transfer relationship with respect to the gas flow, discharging therefrom into the outlet headers 65, from whence it is delivered to the point of use.

In accordance with this invention it will be noted that the headers in the steam heating portion of the unit are disposed in vestibules formed in the side walls thereof, and are thus disposed out of the main gas path.

Means is provided for withdrawing lower temperature gases after passage thereof over the vapor heating means and for recirculating the same through the radiation chamber 24. According to this invention this is accomplished by a recirculating gas fan 66 which is arranged to remove portions of the gases from the breeching 67 via flues 68. The gases pass downwardly therethrough and are delivered into a distributing or manifold duct 69 which circumscribes the setting in the vicinity of the transition zone 24C. A plurality of ducts 70 in communication with the manifold duct 69 supplies the gases through openings or nozzles 71 spaced along the front and rear wall for introduction into the lower furnace chamber 24A at a point below the transition zone 24C. The openings or nozzles 71 are arranged to introduce the circulated gases into the radiation chamber in a manner so as to thoroughly mix with the products of combustion flowing upwardly from chamber 24A. As a result the temperature of the gases entering the convection section 25 is maintained below the fuel ash fusion temperature. Damper means 72 in the recirculation gas flue regulates the amount of gas recycled. At maximum steam output the gas recirculation rate is approximately 30% of the gases generated by the combustion of the fuel.

According to this invention the total gas mass flows vertically through the setting and is divided in the upper portion thereof into a pair of parallel gas streams flowing through passes 39 and 40, the amount of gases flowing therethrough being controlled by proportioning dampers 76, 77, which in conjunction with the steam attemperator (not shown) function to control final superheat and reheat steam temperatures. In addition the steam attemperator also functions to control the temperature of the steam entering the secondary superheater.

Combustion air for the cyclone furnaces 26 is supplied by a forced draft fan (not shown) through an air heater in communication with air supply ducts 74 which are arranged to individually supply corresponding cyclone furnaces each supply duct being provided with a venturi section (not shown) for metering the amount of combustion air supplied.

From the foregoing description it will be readily apparent that the completely vertical and substantially symmetrical setting arrangement minimizes erection difficulties. Further the arrangement of the unit is such that the surfaces thereof are completely drainable, thereby facilitating starting and cleaning of the unit. The vertical arrangement and the spacing of the vapor heating surfaces are such that in the event that ash dislodged from any of the heat absorption surfaces it will fall to the bottom of the unit permitting all of the ash to be withdrawn from a single molten slag collecting zone.

While the instant invention has been disclosed with reference to a particular embodiment thereof, 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.

We claim:

1. A vapor generating and superheating unit comprising vertical front, rear and side walls defining a setting including a radiation section and a convection heating section connected thereto for gas flow serially therethrough, a liquid and vapor separating drum, vertically extending vapor generating tubes connected for fluid flow therethrough with said drum lining said setting walls, a cyclone furnace disposed for discharging hot combustion gases into said radiation section through a wall portion of said setting, said cyclone furnace being defined by a wall of fluid cooled tubes, cyclone furnace riser tubes in communication with and receiving fluid discharged from said cyclone furnace wall tubes, said riser tubes extending upwardly into aligned relationship with said generating tubes lining said setting walls and connected for fluid flow therethrough with said drum, and means including a first liquid header for supplying said setting wall tubes and a second separate and distinct liquid header for supplying said cyclone furnace wall tubes, and downcomers connecting each of said headers to said drum so that said riser tubes and setting wall tubes are connected into separate and distinct fluid downflow supply systems.

2. A vapor generating and superheating unit comprising vertical front, rear and side walls defining a setting including a radiation section and a superposed convection heating section connected for gas flow serially therethrough, a liquid and vapor separating drum disposed at the top of said setting, vertically extending vapor generating tubes lining said setting walls and connected for fluid flow with said drum, a plurality of cyclone furnaces disposed in said front and rear walls discharging hot combustion gases into said radiation section, each of said cyclone furnaces being defined by a wall of fluid cooled tubes, cyclone furnace riser tubes in communication with said furnace wall tubes, said riser tubes extending upwardly into aligned contiguous, heat absorbing relationship with said generating tubes lining said front and rear walls; and means connecting said riser tubes and setting wall tubes into separate and distinct fluid downflow supply systems, said means including a first liquid header

connected in fluid flow relationship with said setting, wall tubes for supplying the same, and a second liquid header connected in fluid flow relationship with each of the cyclone wall tubes, and downcomers directly connecting each of said first and second headers to said drum.

3. A vapor generating and superheating unit comprising vertical front, rear and side walls defining a setting including a radiation section and a superposed convection heating section connected for gas flow serially therethrough, vertically extending vapor generating tubes lining the front and rear walls of said radiation section, said generating tubes being inwardly bent to extend toward the center of said setting to form a tube screen separating said radiation section from said convection section, a division wall of vapor generating tubes dividing said convection heating section into parallel gas passes, said division wall tubes comprising vertical extensions of said screen tubes, vapor heating tubes disposed in said convection heating section, a plurality of cyclone furnaces disposed in said front and rear walls discharging hot combustion gases into said radiation chamber through the front and rear walls of said setting, said cyclone furnace being defined by a wall of fluid cooled tubes, riser tubes in communication therewith and extending upwardly into aligned contiguous heat absorbing relationship with said generating tubes lining said front and rear walls; and means connecting said riser tubes and setting wall tubes into separate and distinct fluid downflow supply systems whereby a predetermined desired quality of vapor liquid mixture is attained in each of said systems with a minimum amount of liquid downflow being supplied thereto.

4. A vapor generator and heating unit comprising a setting having front, rear and side fluid cooled walls defining a radiation section and a superposed heat absorbing section, a plurality of cyclone furnaces disposed in the front and rear walls in the lower portion thereof and opening into said radiation section, each of said cyclone furnaces being defined by a wall of fluid cooled tubes, a liquid-vapor drum supported adjacent the top of the setting, a liquid header encircling the lower portion of the setting, a liquid cross header extending transversely of the setting adjacent the bottom thereof and a plurality of downcomers longitudinally spaced along the drum for directly connecting the drum in fluid circulation to said encircling header and cross header respectively, said cross header connected to and supplying the front, side and rear fluid cooled walls of said setting and said encircling header connected to and supplying the fluid cooled tubes of said cyclone furnaces whereby the flow through said walls of said setting and cyclone furnaces respectively are rendered separate and distinct downflow supply systems whereby a predetermined desired quality of vapor liquid mixture is attained in each of said systems with a minimum amount of liquid downflow being supplied thereto.

5. The invention as defined in claim 4 including a first and second pair of downcomers longitudinally spaced along the liquid-vapor drum, said first pair connecting the vapor drum to said encircling header and said second pair disposed between said first pair and connecting said vapor drum to said cross header.

6. A natural circulation vapor generating and heating unit adapted to burn a slag producing fuel comprising a setting having front, rear and side fluid cooled walls, said walls enclosing a radiation section and a vertical superposed convection heating section having vapor heating means disposed therein, said radiation section having a lower primary radiation chamber and a superposed enlarged secondary radiation chamber, said front and rear fluid cooled walls adjacent the upper portion of said primary radiation chamber diverging outwardly to form an unobstructed transition section between the upper and lower chambers, a plurality of laterally extending and spaced apart cyclone furnaces disposed in the front and rear walls of said primary radiation chamber, said cyclone furnaces of one wall being staggered relative to those in the other and arranged to discharge hot gaseous products of combustion directly into said primary radiation chamber so that gas distribution across the setting is enhanced, said setting being arranged to flow said uniformly distributed gases upwardly therethrough, and means for withdrawing heating gas after passing through said convection heating section and recirculating the same through said radiation section, said gas being introduced into said section below said transition section whereby the recirculated gas and hot combustion gases are mixed as they flow from the lower radiation chamber through the transition section and into the enlarged upper chamber.

7. The invention as defined in claim 6 in which said fluid cooled walls include a group of closely spaced generating tubes lining said front and rear walls, said group of generating tubes having certain tubes thereof intermediate the length thereof inwardly bent to extend toward the center of said setting forming a screen section separating said secondary radiation chamber from the convection heating section, and a fluid cooled division wall dividing said convection section into a pair of parallel gas passes, said division wall comprising vertically extending tube members comprising a continuation of said screen forming tubes.

8. The invention as defined in claim 7 wherein said tube portions in the screen section have a smaller internal diameter than the tube portions forming the division wall and/or lining said front and rear walls.

9. A vapor generator and heating unit comprising a setting having front, rear and side fluid cooled walls enclosing a radiation section and a superposed convection heating section having vapor heating means disposed therein, said radiation section including a diverging lower radiation chamber, an upper enlarged radiation chamber and a diverging transition section connecting said relatively small radiation chamber to said upper enlarged radiation chamber, said front and rear fluid cooled walls each including a plurality of vapor generating tubes extending therealong, said tubes each including a lower segment lining the front and rear walls of the primary radiation chamber, said tubes being bent outwardly and upwardly to line the wall portions of said transition section, adjacent tubes along the upper portion of said transition section connect into an intermediate tube portion having an increased diameter and extending upwardly to line the walls of said upper radiation chamber and said tubes adjacent the upper end of the radiation section being inwardly bent to extend toward the center of said setting forming a screen section for separating said upper radiation chamber from said convection heating section, said tube portions forming the screen section having a reduced diameter, and a fluid cooled division wall dividing said convection heating section into a pair of parallel gas passes, said division wall comprising vertically extending tube members which constitute a continuation of said screen forming tubes, said division wall tubes having a diameter greater than that of the screen tube segment from which said division wall tubes extend whereby said vapor generating tubes are each subjected to substantially the same heat absorption pattern throughout their length.

10. A natural circulation vapor generator and heating unit comprising a setting having front, rear and side fluid cooled walls enclosing a radiation section and a superposed convection heating section having vapor heating means disposed therein, said radiation section including a diverging lower radiation chamber, an upper enlarged radiation chamber and a diverging transition section connecting said relatively small radiation chamber to said upper enlarged radiation chamber, said front and rear fluid cooled walls each comprising a plurality of closely spaced generating tubes extending therealong, said tubes each including a lower segment lining the front and rear walls of the primary radiation chamber, said

tubes being bent outwardly and upwardly to line the wall portions of said transition section, adjacent pairs of said lower tubes segments at the upper portion of said transition section connect into a single tube segment of increased diameter extending upwardly to line the walls of said upper radiation chamber and said latter tube segment adjacent the upper radiation section being inwardly bent to extend toward the center of said setting forming a screen section separating said upper radiation from said gas convection pass, a cyclone furnace disposed for discharging hot combustion gases into said radiation section through a wall portion of said setting, said cyclone furnace being defined by a wall of fluid cooling tubes, cyclone riser tubes in communication with and receiving fluid discharging from said cyclone furnace fluid cooling tubes extending upwardly between alternate wall tubes to complement said wall tubes, said cyclone riser tubes being bifurcated immediately above said screen and extended upwardly therefrom to form a tubular fluid cooled wall in the intermediate portion of the convection heating section whereby each of said cyclone riser tubes is similarly disposed so as to be subjected to substantially the same heat absorption pattern, said screen forming tube sections having a relatively smaller diameter than said tube segments in said walls and a fluid cooled division wall dividing said convection heating section into a pair of parallel gas passes, said division wall comprising vertically extending spaced tube members which constitute a continuation of said screen forming tubes, said division wall tubes having a diameter greater than that of the screen tube section from which they extend whereby each of said vapor generating tubes is similarly disposed so as to be subjected to substantially the same heat absorption pattern whereby the latter is distinct from said first mentioned pattern.

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