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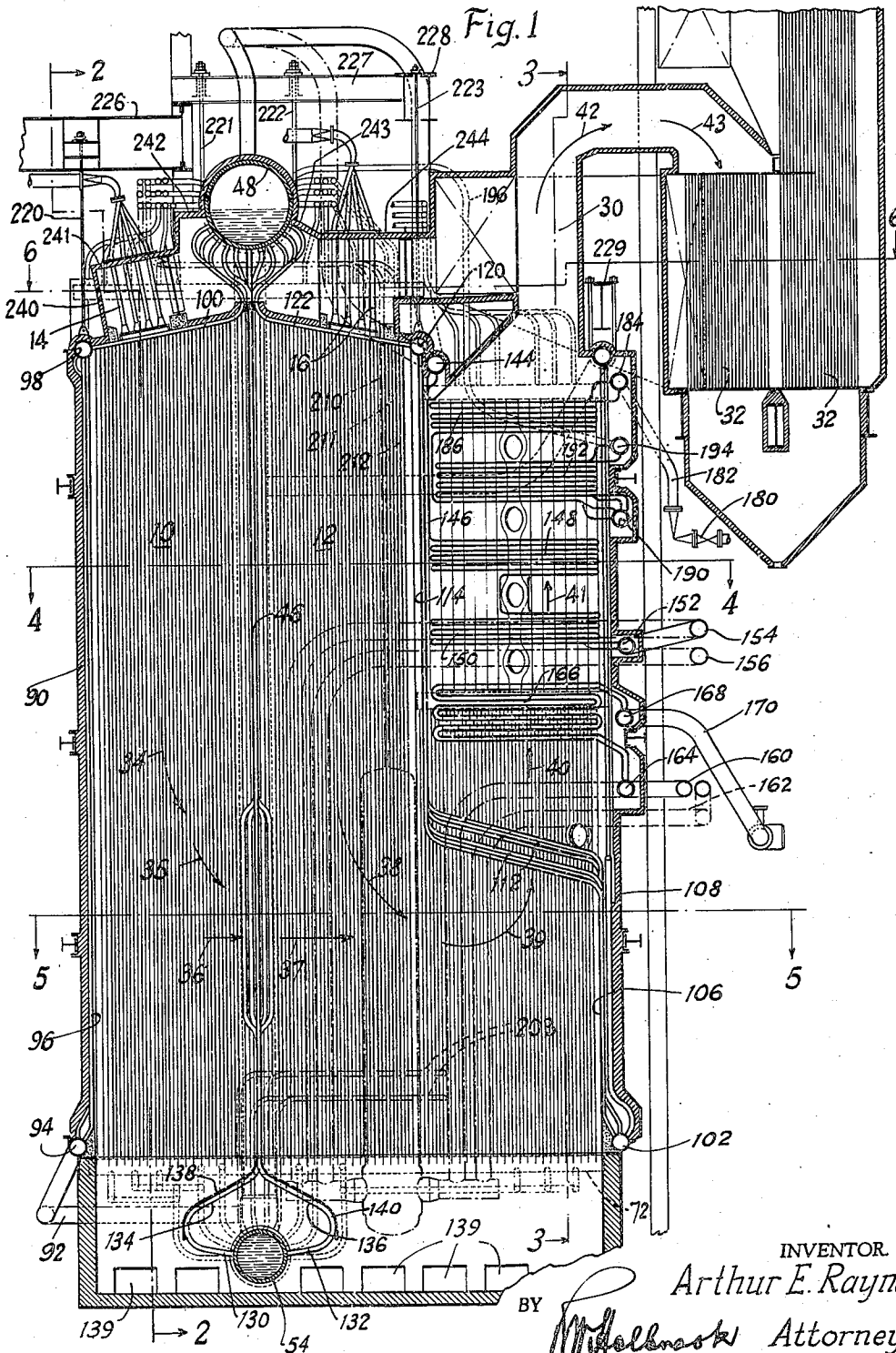
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STEAM GENERATOR

Filed June 14, 1941

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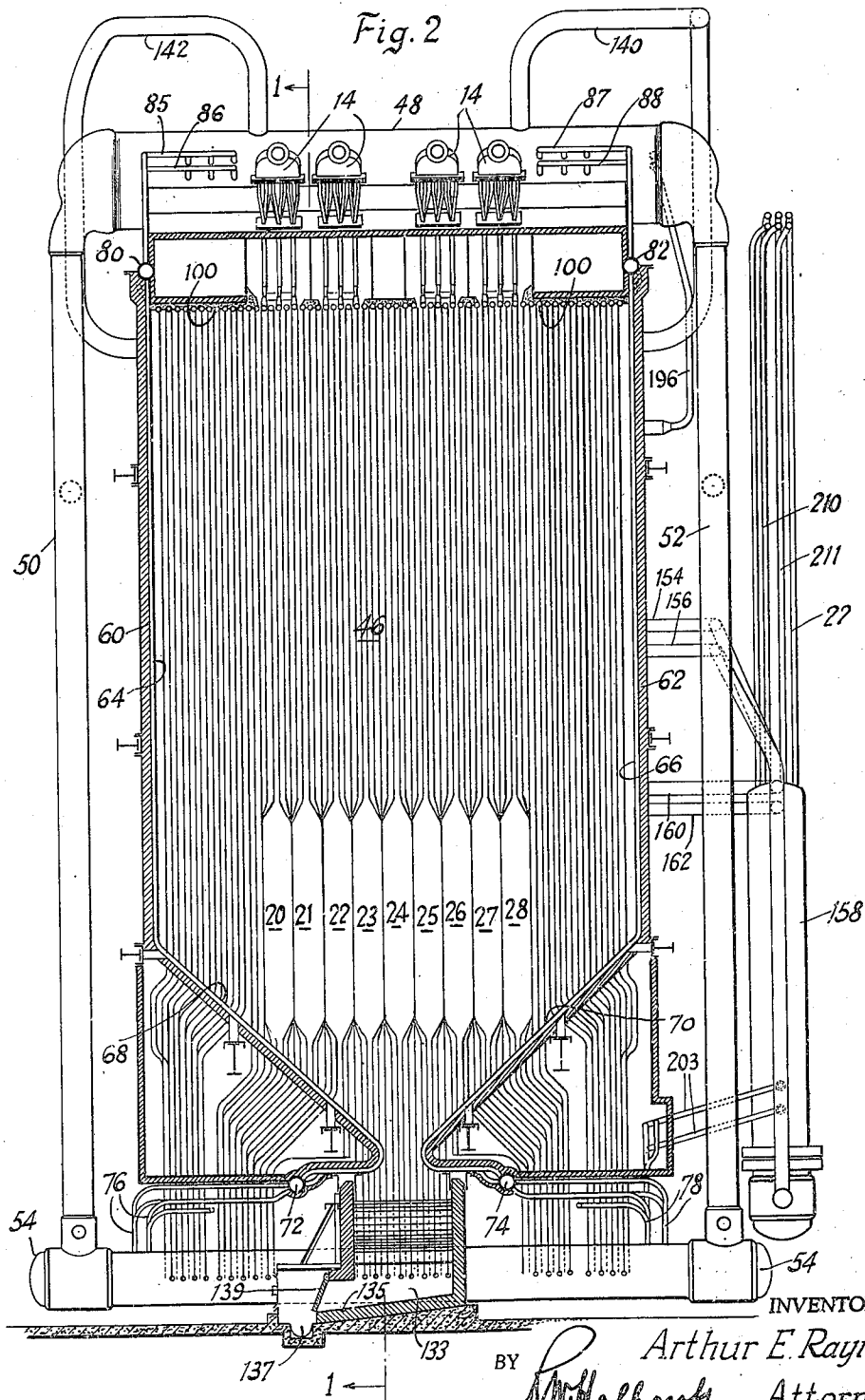


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Fig. 2



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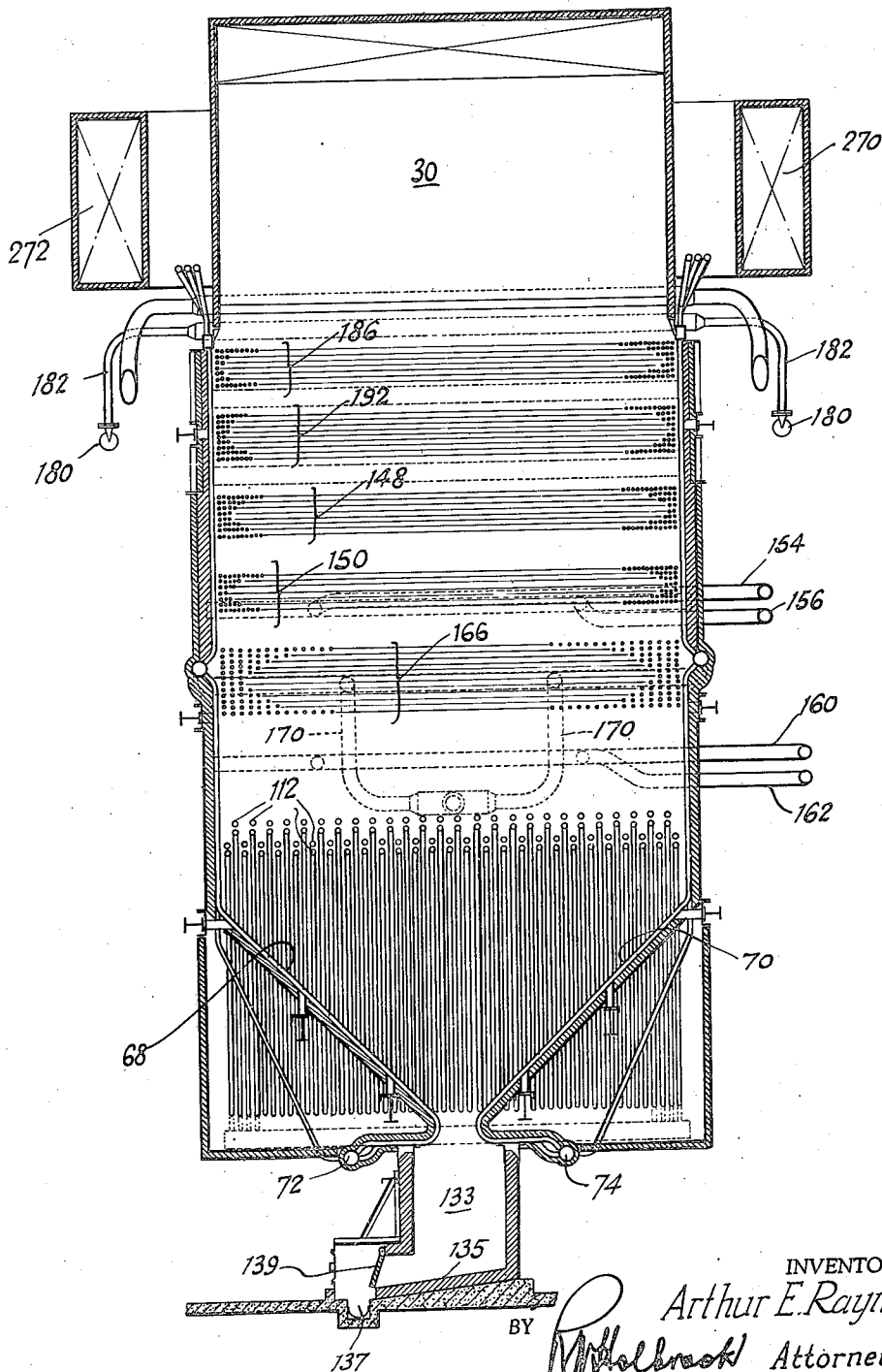
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STEAM GENERATOR

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Fig. 3



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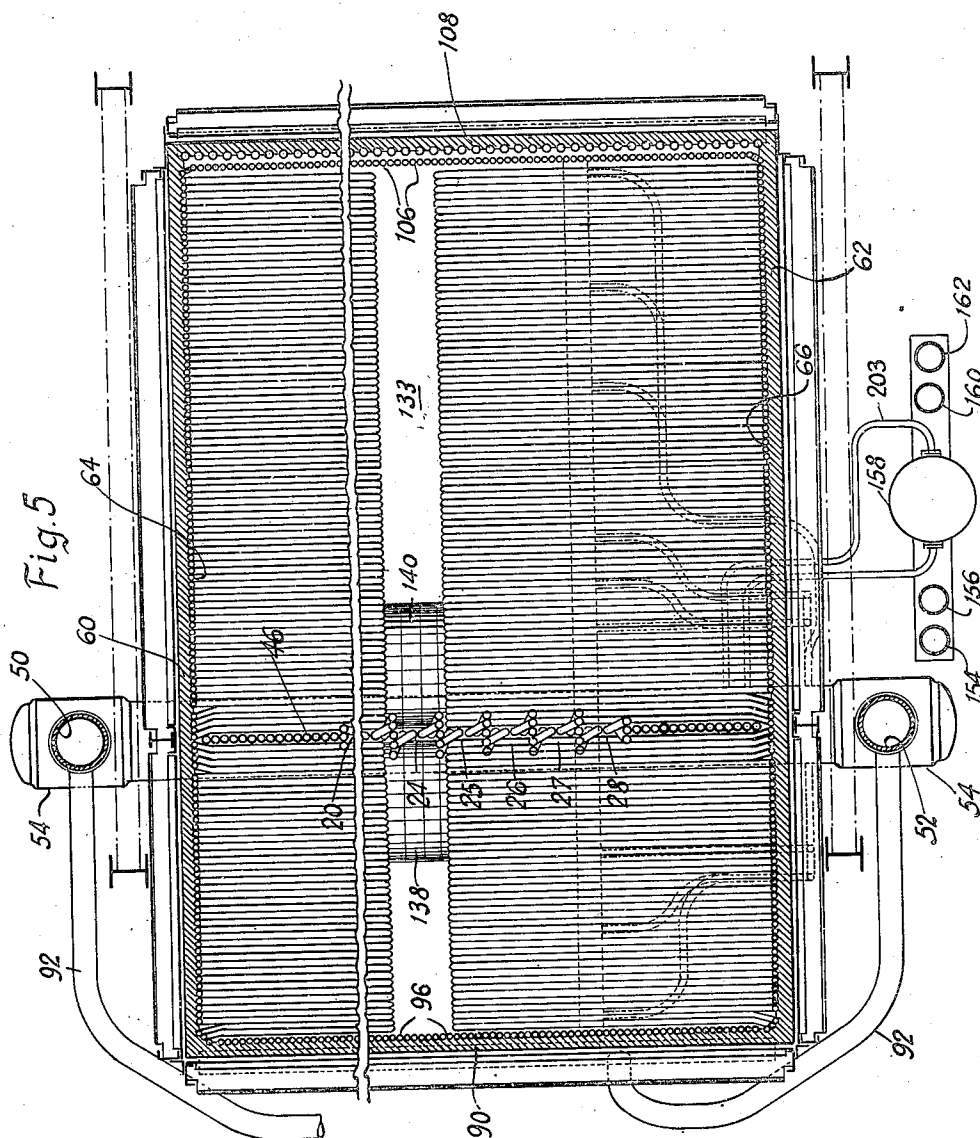
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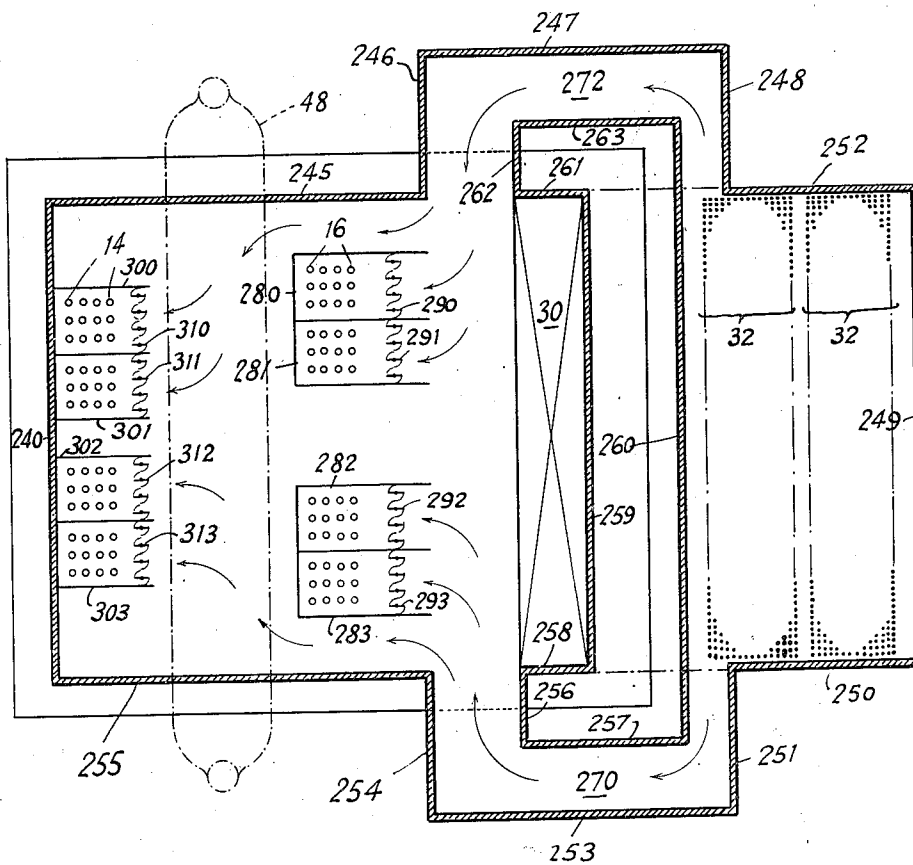
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Fig. 6



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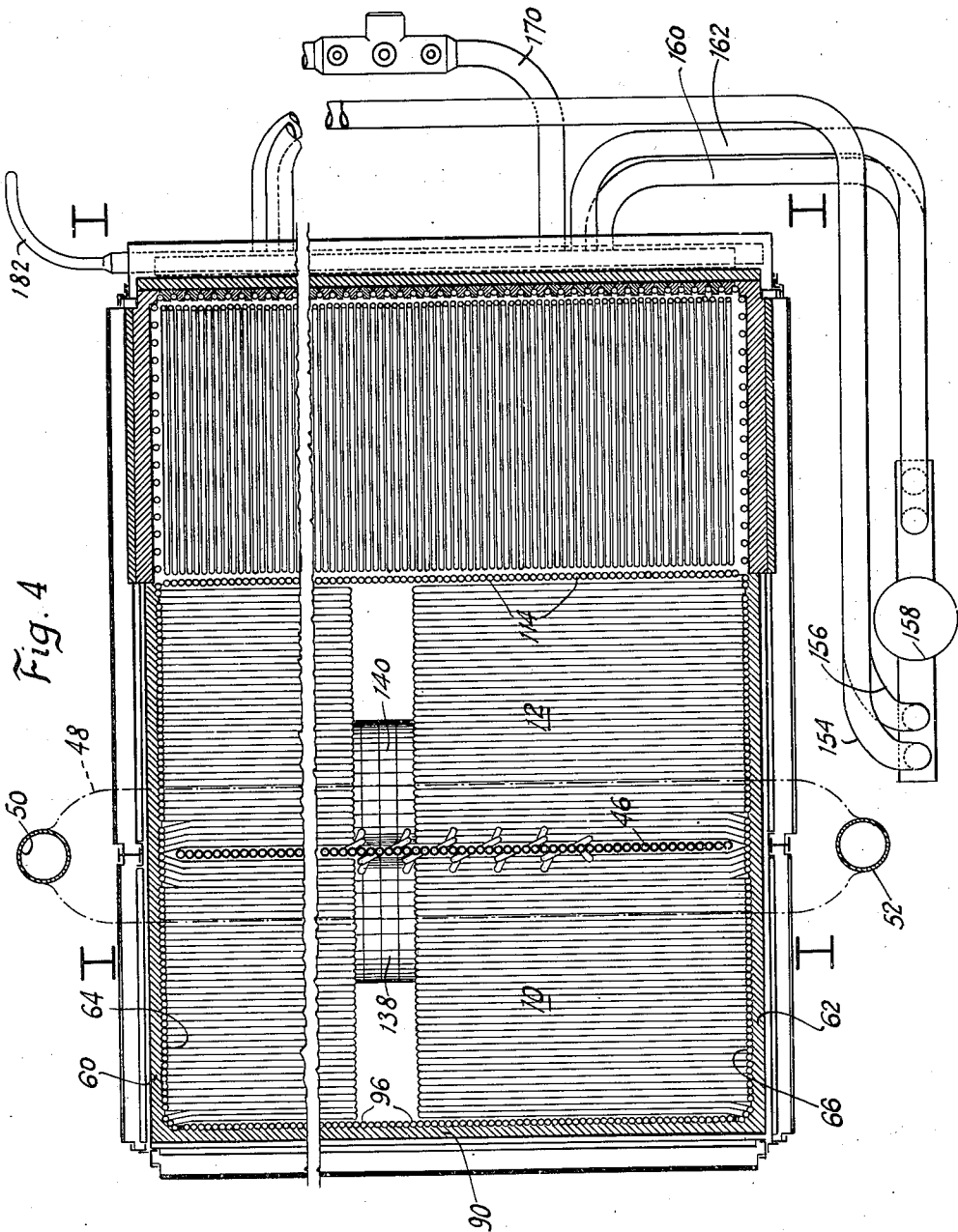
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## UNITED STATES PATENT OFFICE

2,330,240

## STEAM GENERATOR

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9 Claims. (Cl. 12-235)

This invention relates to steam generation, an object of the invention being to accomplish economical and efficient generation of steam throughout a wide range of boiler load requirements, without sacrifice of combustion efficiency.

The invention also relates to the construction and operation of vapor generators and more particularly to steam generating units characterized by low construction cost, low maintenance, and low floor space requirements.

Another object of the invention is the provision of a vapor generator which is further characterized by simplicity of construction, high operating efficiency, and ease of accessibility to all portions of the unit.

A further object of the invention is the provision of a vapor generator including a fluid cooled furnace fired by pulverized ash bearing fuel, the position of the fuel introduced and the position of the exit of the products of combustion being such that ash particles released by combustion are cooled in their downward flow and are deposited in a subjacent space.

A more specific object of the invention is the provision of a pulverized fired steam generator in combination with an air heater for combustion air, the combination involving an advantageous arrangement of fuel burners and air heater. In this combination the fuel burners are arranged closely adjacent the air heater so that the air ducts therebetween are of minimum length, the combination thus materially contributing to improved efficiency and low construction cost.

The invention will be described with reference to the accompanying drawings which show a steam generating unit having a plurality of furnaces connected in series as to gas flow, these furnaces having a long straight furnace wall construction, and being arranged for the effective utilization of all furnace volume either as combustion space or as a subjacent ash cooling zone.

In the drawings:

Fig. 1 is a view in the nature of a vertical section at a position indicated by section line 1-1 of Fig. 2;

Fig. 2 is a vertical section along a plane at right angles to the plane of Fig. 1 and indicated by section line 2-2 of Fig. 1;

Fig. 3 is a vertical section on the line 3-3 of Fig. 1;

Fig. 4 is a horizontal section on the line 4-4 of Fig. 1;

Fig. 5 is a horizontal section on the line 5-5 of Fig. 1; and

Fig. 6 is a plan, or horizontal section on the

section line 6-6 of Fig. 1, showing the relative arrangement of the drum, fuel burners, air heater and the casing through which secondary air passes to the burners.

The divided furnace construction illustrated in Fig. 1 of the drawings contributes to flexibility of operation under variable loading by reason of selective control of combustion in the separate combustion chambers 10 and 12. By such selective firing regulation heat liberation per unit of wall cooling surface can be varied in accordance with the load requirements.

Fig. 1 illustrates sets of pulverized fuel burners 14 and 16, arranged at the tops of the combustion chambers 10 and 12. When both sets of burners are in operation, furnace gases flow from the combustion chamber 10 through the gas outlets 20-28 (see Fig. 2) to the lower part of the combustion chamber 12 where they are joined by the furnace gases from the latter. The combined gases then flow upwardly over the tubular elements of the convection section and thence to a flue or duct 30 leading to the air heater 32. In Fig. 1, this flow of the gases is indicated by the arrows 34-43.

The combustion chambers 10 and 12 of the Fig. 1 unit are defined by long straight upright walls including wall tubes connected into the boiler circulation. With this arrangement of flow elements, high rates of heat absorption are possible. By the selective operation of the burners, there may be a wide variation in the ratio of heat liberation to heat absorption by the combustion chamber walls.

The combustion chambers 10 and 12 are separated by a partition wall 46 formed by wall tubes directly connected at their upper ends to the water space of the steam and water drum 48. The tubes of the partition wall 46 are connected at their lower ends to a submerged drum 54 disposed beneath the combustion chambers 10 and 12. The large diameter downcomers 50 and 52 (see Fig. 2) connect the ends of the steam and water drum 48 with the submerged drum 54.

The steam generating wall tubes defining the remaining walls of the combustion chambers 10 and 12 have their lower ends connected to the submerged drum 54. For example, the side walls 60 and 62 (see Fig. 2) include the upright wall tubes 64 and 66, the lower ends of which are supplied with water from the submerged drum 54 through the headers 72, 74, and the tubes 76, 78. The lower portions of these tubes extend along the inclined sides 68 and 70 of the ash

hopper, and are bent under the lower parts thereof so as to communicate with the headers 72 and 74.

Steam and water rising in the side wall tubes 64 and 66 passes to the upper headers 80 and 82 and thence through the tubular connections 85—88 to the drum 48.

For the front wall 90 (Fig. 1) water flows from the submerged drum 54 through the conduit 92 to the lower wall header 94. From this header it flows upwardly into the steam generating wall tubes 96 to the upper header 98, and thence with the generated steam through the roof tubes 100 to the drum 48.

The lower water wall header 102 at the rear wall of the setting receives water from the drum 48 and acts as an agency through which that water is supplied to the rear wall tubes 106 along the wall 108. At the position 110 these tubes are bent so as to present horizontally inclined sections forming the screen 112 extending across the gas entrance to the convection section. Beyond this screen the tubes extend vertically to define the wall 114 separating the convection section from the furnace 12. Steam generated in these tubes passes to the upper rear wall header 120 and thence through the roof tubes 122 to the drum 48 in the manner indicated in Fig. 1 of the drawings.

The wall 46 separating the furnaces 10 and 12 includes wall tubes 130 and 132, the latter of which communicate with the drum 54 at one side thereof and the former at the opposite side thereof, as indicated at the bottom of Fig. 1. These opposite rows of tubes are bent toward each other at a position above the drum 54 so that they present the horizontally and downwardly inclined sections 134 and 136. To prevent the accumulation of ash particles upon the drum 54 and other tubular connections associated therewith, the inclined tube sections 134 and 136 are covered by cast-iron blocks 138—140. From this zone the tubes 130—132 extend upwardly in single row alignment to the zone of the gas outlets 20—28. These outlets are formed by bending some of the tubes out of their single row arrangement and into the furnace 12 while some of the remaining tubes are similarly bent into the furnace 10. Such formations of the tubes to provide the gas outlets are indicated particularly in Figs. 1 and 5.

From an inspection of Fig. 2, it will be observed that the gas outlets 20—28 of the combustion chamber 10 are located partially in the ash disposal zone. Thus, furnace gases and their suspended products in the combustion chamber 10 travel downwardly in a relatively long path throughout which they are subjected to the cooling effect of the furnace walls. Furthermore, the gases passing through the outlets 20—28 make their turn at a position near the lower end of the combustion chamber, both sets of circumstances promoting the separation of the ash particles which, cooled by the hopper and wall tubes, are disposed in the ash pit 133.

The water cooled hopper bottom construction illustrated in Fig. 2, extends from the combustion chamber 10, past the partition wall 46, across the bottom of the combustion chamber 12, and below the convection section. The hopper bottom construction and the ash pit thus may be said to be continuous across the lower part of the unit, except for its interruption by the submerged drum 54 and the tubes of the partition wall 46.

In Figs. 2 and 3 the ash pit 133 is shown as

having a floor 135 inclined downwardly to a sluiceway 137. Normally, the ash pit is closed by the doors 139 which may be opened to provide for the periodic removal of the ash to the sluiceway 137.

From an inspection of Fig. 5 of the drawings, it would be noted that there is a gap between each vertical edge of the partition wall 46 and the side walls 60 and 62. This arrangement serves as a means for equalization of pressures between the combustion chambers 10 and 12 when the burners for one of them are not operating. This provision is also of importance in taking care of abrupt changes in pressure conditions in the combustion chambers.

Steam, generated by the furnace wall tubes, is separated from the water in the drum 48, and passes through conduits 140 and 142 to the superheater header 144. This header is disposed at one side of the gas pass of the convection section and it communicates, by means of the tubular sections 146, with the tubular coils of the superheater sections 148 and 150. Steam flowing through these coils passes to the superheater outlet header 152, and thence through the conduits 154 and 156 to one side of the attemperator 158. From the other side of the attemperator, the steam, conditioned as to temperature, passes through the conduits 160 and 162 to the inlet header 164 of the superheater section 166. From the outlet header 168 of this section, steam passes through a conduit 170 to the point of use.

Feed water passes through the valve 180 to the conduit 182 and thence to the economizer inlet header 184. From this header the water passes through the coils of the counterflow economizer section 186 to the intermediate header 190 which also might be considered as an inlet header for the coils of the parallel flow economizer section 192. The feed water, together with the steam generated therefrom, passes from the coils of the economizer section 192 to the economizer outlet header 194, and thence through the conduits 196 to the drum 48.

In the attemperator 158 the steam is subject to a controlled amount of cooling by reason of the flow of water to the attemperator through the conduits 203 which communicate with the drum 54. Circulation of water through the attemperator is completed by the risers 210—212 which connect the upper part of the attemperator shell with the drum 48.

The drum 48 and the upper water wall headers are supported by straps or hangers 220—223, from the elements 226—229 of the setting steel work, and all of the pressure parts associated with the furnace walls are thus supported so as to be free to expand downwardly.

The space between the furnace roof tubes 100 and 122 and the drum 48 is enclosed by the walls 240—244 (Fig. 1) which are associated with other walls 245—263 (Fig. 6) to form a casing and ductwork through which secondary air may pass from the air heater 32 to the sets of burners 14 and 16, the illustrative arrangements of air heater, burners, and the casing for the secondary air being such that a minimum of casing or ductwork is required.

Fig. 6 particularly illustrates the relative arrangement of the drum 48, the sets of fuel burners 14 and 16, air heater 32, and the casing or ductwork through which secondary air passes from the air heater to the burners. The air heater is of a tubular type with furnace gases passing through upright tubes. Air passes

around these tubes and then through the short lateral ducts 270 and 272. It then passes to the casing at the top of the furnaces as indicated by the arrows in Fig. 6. The secondary air ports for the burners 16 are enclosed by the casings 280—283 which have associated therewith sets of flow regulators 290—293. Similarly, the sets of burners 14 on the other side of the drum 48 have their air ports within casings 300—303 controlled by sets of air regulators 310—313.

The compact arrangement of the fuel burners and the air heater relative to the associated parts of the unit not only minimizes installation costs by reducing ductwork to a minimum, but it also minimizes heat losses and otherwise promotes high efficiency. It will be noted that the air heater is in substantially the same horizontal zone as the burners and that it is disposed closely adjacent thereto. Furthermore, the secondary air leaving the air heater elements passes around the furnace gas flue and then into an enclosure which constitutes a casing for the top of the furnaces and ductwork for supplying secondary air to the burners.

What is claimed is:

1. In a vapor generator, an upper elongated steam and water drum, a subjacent pulverized fuel furnace, means forming a convection heat absorbing pass receiving furnace gases from the furnace, means forming hopper bottom surfaces for the furnace, fluid cooled furnace wall tubes parts of which extend along the hopper bottom surfaces and co-operate with said means to provide an elongated ash discharge throat extending transversely of the drum and below the entrance to the convection pass, means forming an ash pit below the ash discharge throat and extending therealong, a partition wall dividing the furnace into two combustion chambers, the partition wall including vertically extending tubes arranged in a row parallel to the axis of said drum, some of said partition wall tubes having portions near the hopper bottom bent out of the plane of the wall to provide gas outlets from one combustion chamber to the other, pulverized fuel burners at the upper portions of the combustion chambers for independently firing them, and means including large diameter downcomers connected to the end portions of said drum to connect the furnace wall tubes into a water circuit from the drum.

2. In a steam generator, a first furnace the walls of which are defined by steam generating tubes, a second furnace including steam generating wall tubes connected into boiler circulation, additional steam generating wall tubes arranged as a partition wall separating the furnaces, said additional tubes being bent out of their wall arrangement at a position toward the lower part of the furnaces so as to provide a furnace gas outlet for the first furnace, means for independently firing the furnaces at positions above said outlets, and a convection section including spaced tubes beyond the second furnace, the tubes of said convection section being exposed to the gases from both of said furnaces.

3. In a steam generator, two independently fired furnaces arranged in series as to gas flow and separated by a partition wall including steam generating wall tubes disposed in wall forming alignment, said partition wall having its lateral edges spaced from the side walls of the furnaces so as to provide free inter-furnace communication to prevent damage to said wall by differential pressures between the furnaces,

the partition wall also being of such construction over at least the major part of its face that no substantial gas flow takes place between its adjoining wall tubes.

4. In a steam generating installation, a steam and water drum disposed at the top of a boiler setting, steam generating furnace wall tubes forming two vertically elongated furnaces below said drum, some of said tubes being disposed in a partition wall alignment between said furnaces and directly below said drum, furnace roof tubes extending from opposite furnace walls toward said partition wall and thence to positions at which they are connected to the drum, down-shot pulverized fuel burners disposed at the tops of said furnace so as to project the elements of combustion between the furnace wall tubes into the furnaces, a vertically elongated convection section including a gas pass extending along the side of one of the furnaces and having its inlet above an offset of one of the furnaces, the tubes of the partition wall being bent so as to provide a gas outlet from the other of said furnaces for the passage of gases to the inlet of the convection section, an air heater adjacent the top of the convection section, and means forming ductwork and a casing for the passage of preheated combustion air from the air heater to the burner positions at either side of said drum, said last named means including the drum and walls at both sides thereof.

5. In a steam generating installation, fluid conducting tubes defining the walls of two vertical elongated pulverized fuel fired furnaces, means for firing said furnaces from the tops thereof, said wall tubes including the partition wall separating the furnaces and formed with openings near the bottom of the furnaces for furnace gases to pass from one furnace to the other, means including some of said wall tubes for defining a vertical elongated convection section arranged alongside one of the furnaces and having its furnace gas inlet directly above a lateral offset of one of the furnaces, the last mentioned wall tubes having parts thereof bent so as to form a furnace gas screen extending across the inlet of the convection section, means including fluid cooled tubes defining a hopper bottom extending across the lower portions of both furnaces and underneath the convection section.

6. In a steam generating installation, means forming furnaces, sets of burners for firing the furnaces, a steam and water drum disposed between said sets of burners, a convection section to which the gases pass from the furnaces, an air heater disposed at substantially the same level as the burners and closely adjacent thereto, said air heater being adapted to be heated by the furnace gases after they have passed through the convection section, and a combined furnace casing and duct work leading from the air outlet of the air heater to the secondary air ports of the burners, said casing enclosing the space between the roof of the furnace and said drum.

7. In a steam generator, a first furnace the walls of which are defined by steam generating tubes, a second furnace including steam generating wall tubes connected into boiler circulation, additional steam generating wall tubes arranged as a partition wall separating the furnaces, said additional tubes being bent out of their wall arrangement at a position toward the lower part of the furnaces so as to provide a furnace gas outlet for the first furnace, means for independ-

ently firing the furnaces at positions above said outlet, said additional tubes being closely spaced over the predominating part of the face of the partition wall so as to limit diffusion of gases from one furnace to the other, and a convection section including spaced tubes beyond the second furnace, the tubes of said convection section being exposed to the gases from both of said furnaces.

8. In a steam generator, a first furnace the walls of which are defined by steam generating tubes, a second furnace including steam generating wall tubes connected into boiler circulation, additional steam generating wall tubes arranged as a partition wall separating the furnaces, said additional tubes being bent out of their wall arrangement at a position toward the lower part of the furnaces so as to provide a furnace gas outlet for the first furnace, burners for independently firing the furnaces at positions above said outlets, said additional tubes being closely spaced from the burner zone downwardly to the level of said outlet to limit diffusion of gases from one furnace to the other when the furnaces are fired differently, and a convection section including

spaced tubes beyond the second furnace, the tubes of said convection section being exposed to the gases from both of said furnaces.

9. In a steam generator, a first furnace the walls of which are defined by steam generating tubes, a second furnace including steam generating wall tubes connected into boiler circulation, additional steam generating wall tubes arranged as a partition wall separating the furnaces, said additional tubes being bent out of their wall arrangement at a position toward the lower part of the furnaces so as to provide a furnace gas outlet for the first furnace, means for independently firing the furnaces at positions above said outlets, said additional tubes being closely spaced from the burner zone downwardly to the zone of said outlet to limit diffusion of gases from one furnace to the other, and a convection section including spaced tubes beyond the second furnace, the convection section having a gas inlet communicating with the second furnace and disposed opposite said gas outlet, the tubes of said convection section being exposed to the gases from both of said furnaces.

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