

Nov. 9, 1943.

G. D. EBBETS ET AL

2,333,644

VAPOR GENERATOR

Filed April 26, 1941

3 Sheets-Sheet 1

Fig. 2

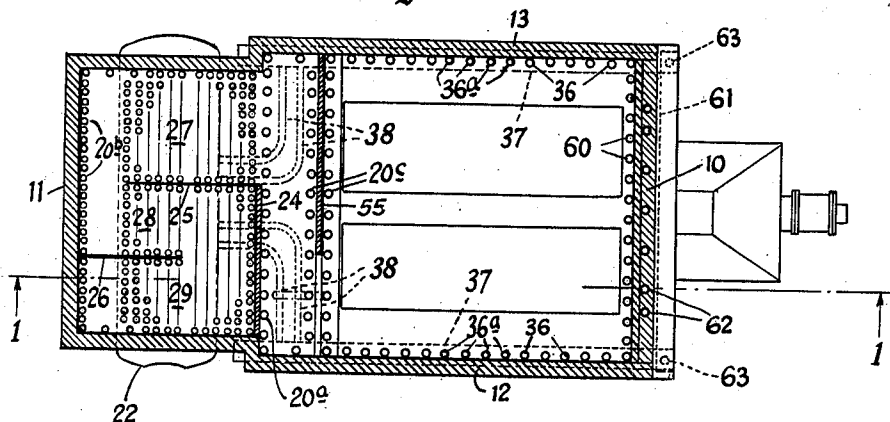
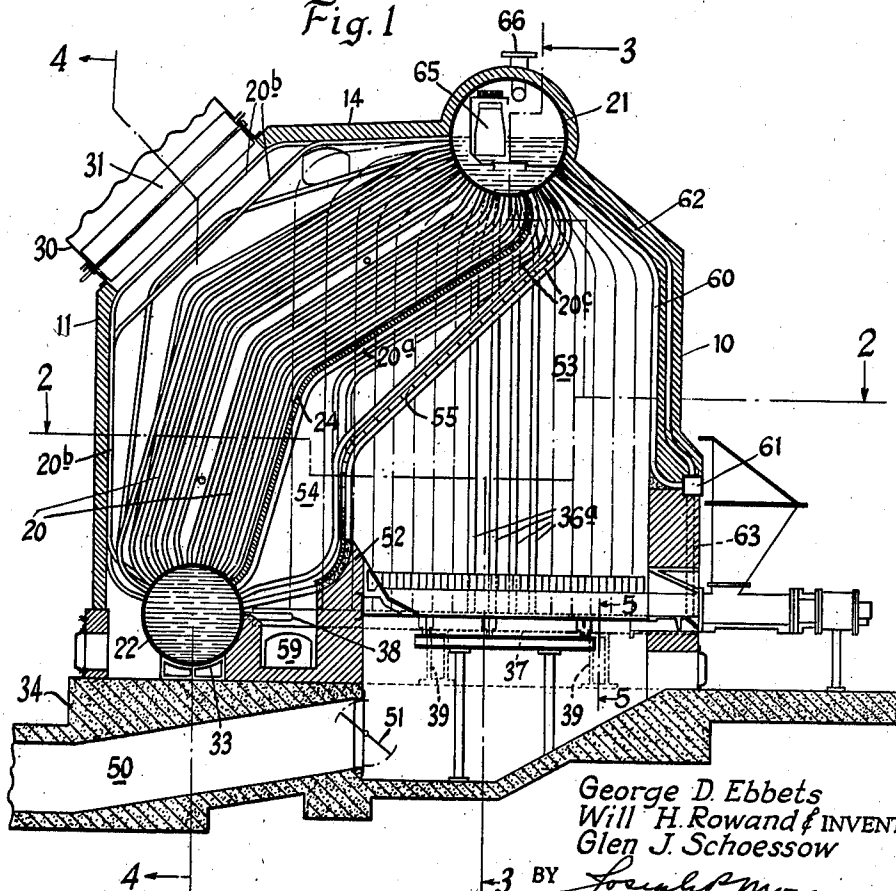


Fig. 1



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3 Sheets-Sheet 2

Fig. 3

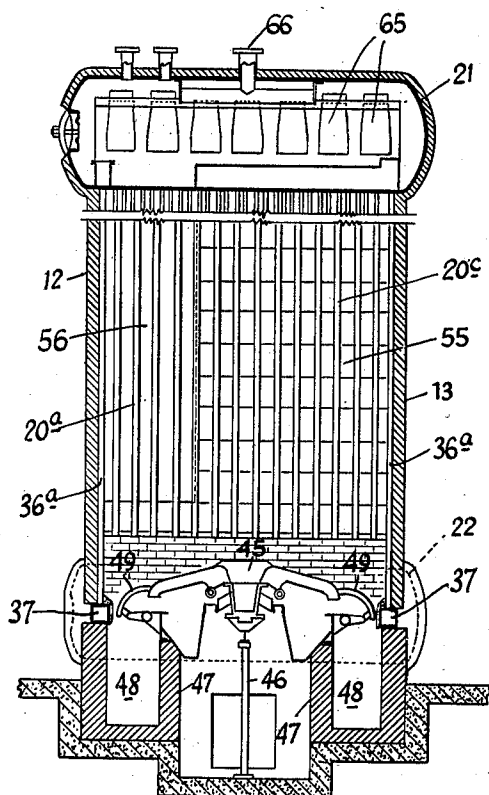


Fig. 4

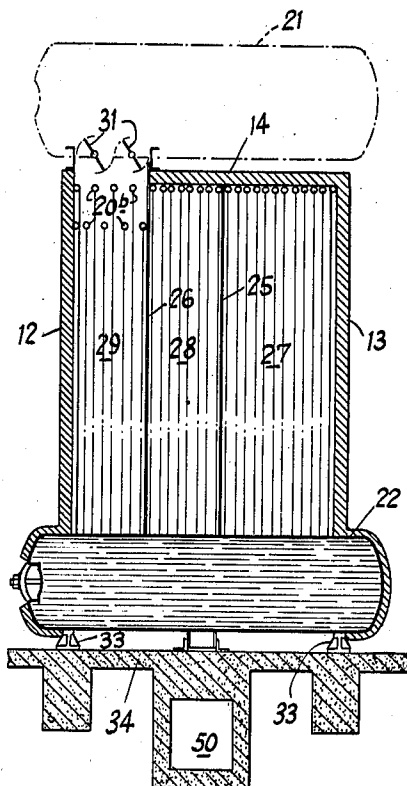


Fig. 5

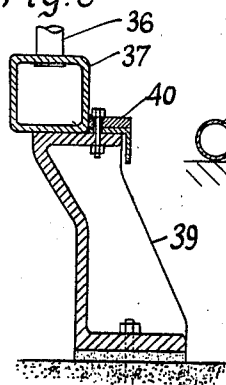
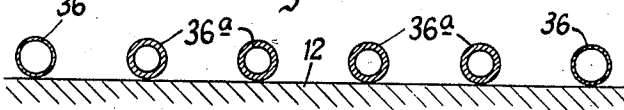


Fig. 6



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3 Sheets-Sheet 3

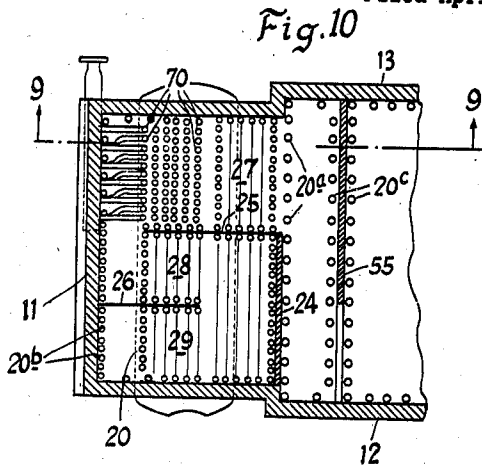


Fig. 8

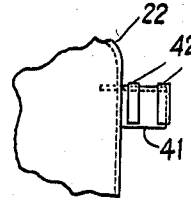
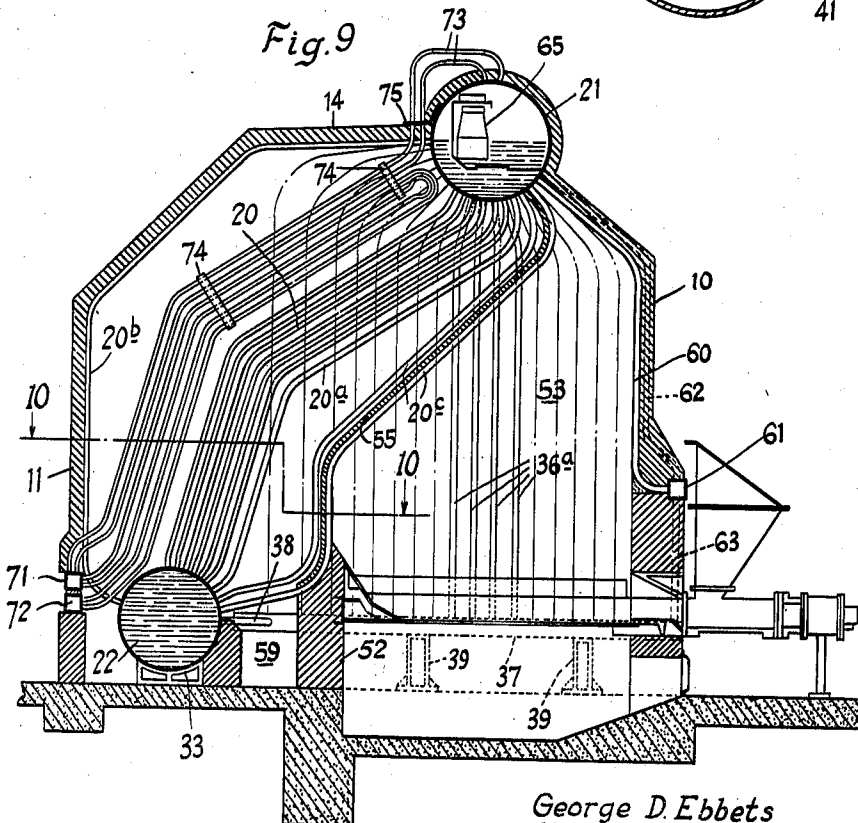
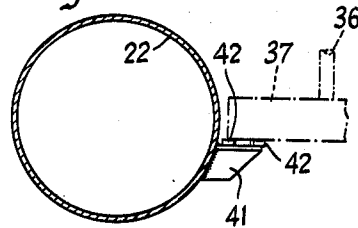


Fig. 7



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UNITED STATES PATENT OFFICE

2,333,644

VAPOR GENERATOR

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Application April 26, 1941, Serial No. 390,486

15 Claims. (Cl. 122—336)

The present invention relates in general to the construction and operation of vapor generators, and more particularly to steam generating units particularly characterized by their low head room and small floor requirements and low cost of construction.

The main object of the invention is the provision of a vapor generator of the character described which is further characterized by its simplicity of construction, high operating efficiency, low cost of maintenance, and ease of accessibility to all portions of the unit.

A further and more specific object is the provision of a vapor generator of the character described in which the pressure parts are entirely bottom-supported, and a major portion of the upper drum loading is carried by a special arrangement and construction of furnace wall tubes.

A further object is the provision of a vapor generator of the general character described which is especially adapted for use with a mechanical stoker as the fuel firing means.

The various features of novelty which characterize our 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 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 several embodiments of our invention.

Of the drawings:

Fig. 1 is a sectional elevation taken on the line 1—1 of Fig. 2 of a steam boiler constructed in accordance with the invention;

Fig. 2 is a horizontal section taken on the line 2—2 of Fig. 1;

Fig. 3 is a vertical section taken on the broken section line 3—3 of Fig. 1;

Fig. 4 is a vertical section taken on the line 4—4 of Fig. 1;

Fig. 5 is a vertical section taken on the line 5—5 of Fig. 1;

Fig. 6 is an enlarged view of a portion of the furnace side wall tubes shown in Fig. 2;

Fig. 7 is a detail elevation of the drum and header support connections;

Fig. 8 is a plan view of the drum support bracket;

Fig. 9 is a view similar to Fig. 1 taken on the line 9—9 of Fig. 10 and illustrating a modified construction; and

Fig. 10 is a horizontal section taken on the line 10—10 of Fig. 9.

In the embodiment of the invention shown in Figs. 1—8, the vapor generator has a setting, substantially rectangular in horizontal and vertical cross-section, formed by a front wall 10, a rear wall 11, side walls 12 and 13, and a roof 14. Within the setting are the pressure parts of the unit, the major portion of the steam generating surface being formed by a bank of small diameter tubes 20 extending between an upper horizontal steam and water drum 21 and a laterally displaced lower water drum 22. As shown, the drums 21 and 22 are laterally offset a considerable distance, the drum 22 extending adjacent the rear wall 11 and the drum 21 intermediate the front section of the unit. The tube bank 20 is formed by rows of "dog leg" tubes arranged parallel except for their end portions which are radially connected to the drums, the upper tube ends being confined to a portion of the drum 21 below the normal water level therein. In order to secure the maximum amount of steam generating surface within the available space limitations, while maintaining desirable circulation conditions therein at all ratings, the lower portions of the tubes 20 are arranged at an angle of approximately 75° to the horizontal, while the upper tube portions are bent forwardly at an angle of approximately 32° to the horizontal.

The setting space containing the tube bank 20 is baffled to provide a flow of heating gases transversely of the tubes in the bank through a series of gas passes arranged longitudinally of the tube bank. For this purpose a tile partition 24 is built up on the innermost tube row 20 at the furnace side of the bank the full distance between the drums and from the side wall 12 approximately half the length of the tube bank. Vertical transverse baffles 25 and 26 extend from the end of the partition 24 and rear wall 11 respectively, as indicated in Fig. 2, partly across the tube bank space to form serially connected transverse gas passes 27, 28, and 29. The two rearmost rows 20 of the tube bank have corresponding portions lining the rear wall 11 and roof 14, and their intermediate portions in the gas pass 29 staggered to provide adequate flow area therethrough to an inclined heating gas outlet flue 30 opening into the upper portion of the pass 29. Dampers 31 in the outlet flue 30 are operable to control the draft through the unit.

The lower water drum 22 rests on spaced supporting cradles 33 carried by the concrete foundation 34, thus providing a bottom support for

the lower water drum and a portion of the weight of the generating tubes 20 and the contents thereof. In view of the substantial lateral displacement of the drums 21 and 22 and the angular arrangement of the upper and lower portions of the generating tubes, the weight of the drum 21 and the upper portion of the generating tube bank and the contents thereof cannot be carried by the described supports and require special supporting provisions. Top supporting of these pressure parts would not only increase the head room requirements of the unit, but also its cost of construction as well as complicating the thermal expansion requirements in operation.

In accordance with our invention, the steam and water drum 21 and upper section of the tube bank 20 are adequately supported without resulting in any increase in the head room requirements or any substantial increase in the cost of construction or number of structural parts than would otherwise be necessary, while at the same time simplifying the thermal expansion requirements of the unit, by a special construction of some of the water tubes used for fluid cooling the furnace side walls 12 and 13 and the support means therefor. As shown, the portion of each side wall between the front wall 10 and tube bank 20 is lined with a row of vertical water tubes 36. The tubes 36 are straight and parallel substantially throughout their entire lengths, with their upper portions curved and radially connected to the end sections of the drum 21 below the normal water level therein. The lower ends of each row of tubes 36 are connected to a horizontal header 37 extending from a point adjacent the drum 22 to the outer side of the front wall 10. Supply tubes 38 connect the drum 22 to the adjacent ends of the headers 37. The drum 22 is anchored at its center to provide symmetrical expansion.

The provisions for supporting each side water wall, as well as a corresponding portion of the weight of the drum 21, upper section of the tube bank 20 and the contents thereof, comprise a pair of support castings 39 between each header 37 and the foundation 34. Each header is expansibly secured to the corresponding support castings 39 by welding a plate 40 onto the lower outer side of the header and bolting the plate through an expansion slot therein to the top of the support casting. The plate slot for the forward support permits movement of the header 37 axially thereof while the rear plate slot permits outward movement as well. In addition to the support castings the four wall tubes 36^a adjacent to the vertical center line of the drum 21 are constructed to serve as support columns between the drum and header. As shown in Fig. 6, the tubes 36^a have the same outside diameter as the remaining side wall tubes 36 with a wall thickness approximately twice that of the remaining tubes 36, thus considerably increasing the compression strength of the tubes 36^a. This arrangement of the thick walled tubes forms an effective means for transmitting the gravity loading on the upper drum 21 to the header 37 and foundation, without increasing the number of side wall tubes required for wall protection. In addition to the support castings, the headers 37 have their ends adjacent the drum 22 tied to that drum by a supporting arrangement which permits relative movement of the drum and headers parallel to the drum axis, but prevents relative movement of these parts transversely of the drum axis. As shown in Figs. 7 and 8, the drum

has a pair of angle brackets 41 welded thereon, each of which carries a pair of transversely spaced bars 42 on its upper side and between which a bar 43 on the underside of the corresponding header end slideably fits. With the described construction and arrangement, all of the pressure parts of the unit will be bottom-supported and thus all vertical thermal expansion of the parts will be upward.

The described formation of the main tube bank and drums, and arrangement of the side wall tubes, is particularly adapted for a stoker fired unit, although broadly the boiler construction would also permit the use of other fuels, such as pulverized or granulated coal, oil or gas. In the construction illustrated, an underfeed type mechanical stoker extends through the front wall 10 with its axis normal to the tube bank, the stoker comprising a center feed and grate section 45 carried by bottom supports 46 and longitudinal walls 47, which are spaced from the bottom portions of the side walls 12 and 13 to form ash pits 48 at opposite sides of the stoker and below the dumping sections 49 thereof. Within the foundation is arranged an air blast tunnel 50 leading from a forced draft fan (not shown) to the center section of the stoker. A damper 51 at the exit end of the tunnel 50 controls the air discharge from the fan.

The underfeed stoker extends rearwardly to a transverse bridge wall 52 in front of and spaced from the lower water drum 22. The portion of the unit forwardly of the tube bank 20 and partition 24 is divided into a main furnace chamber 53 and an open pass 54 by a second partition 55 formed by tile blocks arranged between a pair of tube rows 20^c extending between the drums 21 and 22. The tubes 20^c and partition 55 are constructed to form a vertically elongated restricted gas exit 56 from the main furnace chamber 53, as shown in Figs. 2 and 3. Access to the open pass is had by bending rearwardly the portions of a pair of tube 20^c extending across the gas exit 56. The gas exit 56 is advantageously located in a portion of the partition 55 adjacent the side wall 12 and opposite the third pass 29. The gas exit extends from the drum 21 to a point above the top of the bridge wall 52. With this arrangement of the gas exit 56 all of the products of combustion from the main furnace chamber will be required to enter the open pass 54 adjacent one end thereof and flow laterally therein to the entrance end of the first gas pass 27. As shown in Fig. 1, the open pass 54 has an upwardly tapering cross-section to provide proper distribution of the heating gases therein and entering the tube bank 20 substantially throughout the height of the gas pass 27. The lower portions of the tubes 20^c between the bridge wall 52 and the drum 22 are substantially horizontal and spaced to permit free passage therethrough of ash separated from the heating gases in the open pass. The space between the bridge wall and the drum 22 forms an ash pit 59 from which deposited ash can be removed through access doors in the side walls.

The front wall 10 is lined with a row of water tubes 60 extending from the drum 21 downwardly to a transverse header 61 at the outer side of the wall. A lesser number of supply tubes 62 are encased in the front wall 10 at the outer side of the tube row 60. The header 61 is connected to and supported from the ends of the headers 37 by short drain tubes 63.

The furnace chamber is thus defined on all sides by water walls discharging into a common upper drum and tied together structurally to one another and to the lower drum at the level of that drum.

The discharge from the riser tubes entering the steam and water drum 21 passes through corresponding cyclone type steam and water separators 65 spaced along the length of the drum and which provide a highly effective separation of the entering steam and water before the steam is discharged through the steam outlet connection 66.

In the operation of the steam generating unit described, the supplies of air and fuel are fed to the furnace in controlled quantities, and combustion of the fuel takes place at a relatively rapid rate. All of the heating gases generated must flow through the restricted gas outlet 56 at one side of the furnace chamber, thus creating a highly turbulent condition in the gases entering the fluid cooled open pass 54. Combustion of unburned fuel particles is rapidly completed in the open pass under these operating conditions, and the heating gases flow substantially horizontally therein to the entrance end of the first pass 27, and serially through the gas passes 27, 28 and 29. Most of the tubes in the third gas pass 29 serves as downcomer tubes for the remaining portion of the bank, and the supply tubes 38 and 62 deliver adequate supplies of water to the furnace water walls. The vertical arrangement of substantially all of the tubes of the unit minimizes ash deposition thereon, and facilitates routine cleaning operations. The steam generating unit disclosed is particularly adapted for central station and industrial units of relatively small capacity and low operating pressures. One installation of the unit illustrated, for example, is designed for a maximum steaming capacity of 42,000 pounds of saturated steam per hour at a pressure of 150 psi.

While the steam generating unit illustrated in Figs. 1-8 is designed for the production of saturated steam only, it can be readily adapted for the production of superheated steam, and such a modified construction is illustrated in Figs. 9 and 10. As shown in these figures, the superheating surface is incorporated by eliminating the rear rows of generating tubes in the first pass 27 and substituting nested rows of superheater tubes 70 extending along and substantially parallel to the generating tubes 20. The superheater illustrated is of the draining type having the lower ends of the tubes connected to superposed inlet and outlet headers 71 and 72 respectively, the header 71 being connected to the steam space of the drum 21 by tubes 73. The tubes 70 and 73 are clamped together in spaced relation by bars 74 and suitable clamping means. The vertical support of tubes 70 and 73 is effected by a plate 75 clamped around the tubes 73 and secured to the drum 21.

While in accordance with the provisions of the statutes we have illustrated and described herein the best forms of our 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 the invention may sometimes be used to advantage without a corresponding use of other features.

We claim:

1. A steam generator comprising walls forming

a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced a substantial distance from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of and extending under the upper part of said tube bank, means for bottom-supporting said upper drum mainly consisting of a plurality of vertical water tubes extending substantially straight downwardly from said upper drum along opposite side walls of said furnace chamber, a header extending along each of said furnace side walls and connected to the lower ends of said side wall tubes, and means for bottom-supporting each of said headers.

2. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced a substantial distance from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of and extending under the upper part of said tube bank, means for bottom-supporting said pressure parts comprising cradle means for bottom-supporting said lower drum, a plurality of vertical drum-supporting water tubes extending substantially straight downwardly from said upper drum along opposite side walls of said furnace chamber, a horizontally arranged header extending along each of said furnace side walls adjacent the level of said lower drum and connected to the lower ends of said side wall tubes, and means for bottom-supporting each of said headers.

3. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced a substantial distance from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of and extending under the upper part of said tube bank, means for bottom-supporting said pressure parts comprising cradle means for bottom-supporting said lower drum, a plurality of vertical drum-supporting water tubes symmetrically arranged relative to the vertical axis of said upper drum and extending substantially straight downwardly from said upper drum along opposite side walls of said furnace chamber, a horizontally arranged header extending along each of said furnace side walls and connected to the lower ends of said side wall tubes, and means for bottom-supporting each of said headers.

4. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of and extending under the upper part of said tube bank, a row of vertically extending drum-supporting water tubes connected to said upper drum at opposite sides of the vertical axis of said upper drum and extending substantially straight downwardly along each of the opposite side walls of said furnace chamber, a horizontally arranged header extending along each of said furnace side walls adjacent the level of said lower drum and connected to the lower ends of said side wall tubes, supply tubes connecting each header to said lower drum, means independent of said supply tubes for

supporting one end of said headers from said lower drum, and separate support means for bottom-supporting each of said headers.

5. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of said tube bank, a row of vertically extending water tubes connected to said upper drum at opposite sides of the vertical axis thereof and extending downwardly along each of the opposite side walls of said furnace chamber, a horizontally arranged header extending along each of said furnace side walls and connected to the lower ends of said side wall tubes, the side wall tubes immediately adjacent the vertical axis of said upper drum having greater compression strength than the remaining side wall tubes, and support means for bottom-supporting each of said headers.

6. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of said tube bank, a row of vertically extending water tubes connected to said upper drum at opposite sides of the vertical axis thereof and extending along each of the opposite side walls of said furnace chamber, a horizontally arranged header extending along each of said furnace side walls and connected to the lower ends of said side wall tubes, the side wall tubes immediately adjacent the vertical axis of said upper drum having the same outside diameter as and thicker walls than the remaining side wall tubes, and a support means for bottom-supporting each of said headers.

7. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of said tube bank, a row of vertically extending water tubes connected to said upper drum at opposite sides of the vertical axis thereof and extending downwardly along each of the opposite side walls of said furnace chamber, a horizontally arranged header extending along each of said furnace side walls adjacent the level of said lower drum and connected to the lower ends of said side wall tubes, the side wall tubes immediately adjacent the vertical axis of said upper drum having greater compression strength than the remaining side wall tubes, supply tubes connecting said side wall headers to said lower drum, means for supporting one end of said headers from said lower drum, a cradle support for said lower drum, and a support means for bottom-supporting each of said headers.

8. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced a substantial distance from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of and extending under the upper part of said tube bank, a substantially vertical partition extending along the furnace side of said tube bank

and defining a heating gas inlet to said tube bank adjacent one end thereof, a second substantially vertical partition at the furnace side of and laterally spaced from said first partition and defining therebetween an open pass opening to said furnace chamber adjacent the opposite end of said tube bank, a mechanical stoker in said furnace chamber arranged normal to the longitudinal axis of said lower drum, a plurality of vertical water tubes connected to said upper drum at opposite sides of the vertical axis thereof and extending substantially straight downwardly from said upper drum along opposite side walls of said furnace chamber, a horizontally arranged header extending along each of said furnace side walls adjacent the level of said lower drum and connected to the lower ends of said side wall tubes, and supply tubes connecting said lower drum to said side wall headers.

9. A steam generator comprising walls forming a setting of substantially rectangular horizontal cross-section containing pressure parts including a lower transverse water drum adjacent the rear wall of said setting, an upper transverse steam and water drum displaced a substantial distance forwardly from said lower drum, and an inclined bank of steam generating tubes connecting said drums, the tubes in said generating bank having substantially their entire length formed by angularly arranged straight portions, a furnace chamber arranged forwardly of and extending under the upper part of said tube bank, a substantially vertical partition extending along the furnace side of said tube bank and defining a heating gas inlet to said tube bank adjacent one end thereof, a second substantially vertical partition at the furnace side of and forwardly spaced from said first partition and defining therebetween an open pass having a restricted opening to said furnace chamber adjacent the opposite end of said tube bank, a mechanical stoker for said furnace chamber arranged normal to the axis of said lower drum and supplying fuel to the furnace chamber space under said upper part of said tube bank, and means for bottom-supporting said pressure parts.

10. A steam generator comprising walls forming a setting of substantially rectangular horizontal cross-section containing pressure parts including a lower transverse water drum adjacent the rear wall of said setting, an upper transverse steam and water drum displaced a substantial distance forwardly from said lower drum, and an inclined bank of bent steam generating tubes connecting said drums, a furnace chamber arranged forwardly of and extending under the upper part of said tube bank, a substantially vertical partition extending along the furnace side of said tube bank and defining a heating gas inlet to said tube bank adjacent one end thereof, a second substantially vertical partition at the furnace side of and forwardly spaced from said first partition and defining therebetween an open pass having a restricted opening to said furnace chamber adjacent the opposite end of said tube bank, a plurality of vertical drum-supporting water tubes connected to said upper drum at opposite sides of the vertical axis thereof and extending substantially straight downwardly from said upper drum along opposite side walls of said furnace chamber, a horizontally arranged header extending along each of said furnace side walls and connected to the lower ends of said side wall tubes, cradle means for bottom-supporting said

lower drum, and means for bottom-supporting each of said headers.

11. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced a substantial distance from said lower drum, and an inclined bank of bent steam generating tubes connecting said drums, a furnace chamber at one side of and extending under the upper part of said tube bank, a substantially vertical partition extending along the furnace side of said tube bank and defining a heating gas inlet to said tube bank adjacent one end thereof, a second substantially vertical partition at the furnace side of and laterally spaced from said first partition and defining therebetween an open pass having a restricted opening to said furnace chamber adjacent the opposite end of said tube bank, a mechanical stoker in said furnace chamber arranged normal to the axis of said lower drum, a plurality of vertical drum-supporting water tubes connected to said upper drum at opposite sides of the vertical axis thereof and extending substantially straight downwardly from said upper drum along opposite side walls of said furnace chamber, a horizontally arranged header extending along each of said furnace side walls and connected to the lower ends of said side wall tubes, cradle means for bottom-supporting said lower drum, and means for bottom-supporting each of said headers.

12. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced a substantial distance from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of and extending under the upper part of said tube bank, means for bottom-supporting said upper drum mainly consisting of a plurality of vertical water tubes extending substantially straight downwardly from said upper drum along opposite side walls of said furnace chamber, a header extending along each of said furnace side walls and connected to the lower ends of said side wall tubes, means for bottom-supporting each of said headers, and a mechanical stoker arranged normal to the axis of said lower drum and supplying fuel to the furnace chamber space under the upper part of said tube bank.

13. A steam generator comprising walls forming a setting containing pressure parts including a lower transverse water drum, an upper transverse steam and water drum laterally displaced a substantial distance from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber at one side of and extending under the upper part of

said tube bank, means for bottom-supporting said upper drum mainly consisting of a plurality of vertical water tubes extending substantially straight downwardly from said upper drum along opposite side walls of said furnace chamber, a header extending along each of said furnace side walls and connected to the lower ends of said side wall tubes, means for bottom-supporting each of said headers, and a mechanical stoker in said furnace chamber arranged normal to the axis of said lower drum and having grate sections extending under the upper part of said tube bank.

14. A steam generator comprising walls forming a setting of substantially rectangular horizontal cross-section containing pressure parts including a lower transverse water drum adjacent the rear wall of said setting, and upper transverse steam and water drum displaced a substantial distance forwardly from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber arranged forwardly of and extending under the upper part of said tube bank, a forwardly inclined partition extending along the furnace side of said tube bank and defining a heating gas inlet to said tube bank adjacent one end thereof, a second forwardly inclined partition at the furnace side of and forwardly spaced from said first partition and defining therebetween an open pass having a restricted opening to said furnace chamber adjacent the opposite end of said tube bank, and a mechanical stoker in said furnace chamber arranged normal to the axis of said lower drum and having grate sections extending under the upper part of said tube bank and partitions.

15. A steam generator comprising walls forming a setting, pressure parts including a lower transverse water drum, an upper transverse steam and water drum displaced a substantial distance forwardly from said lower drum, and an inclined bank of steam generating tubes connecting said drums, a furnace chamber arranged forwardly of and extending under the upper part of said tube bank, a forwardly inclined partition extending along the furnace side of said tube bank and defining a heating gas inlet to said tube bank adjacent one end thereof, a second forwardly inclined partition at the furnace side of and forwardly spaced from said first partition and defining therebetween an open pass, said second partition having an opening in the upper part thereof providing a restricted gas connection between said open pass and said furnace chamber adjacent the opposite end of said tube bank, and fuel burning means for said furnace chamber arranged below the lower level of said restricted gas connection.

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