

Sept. 10, 1935.

W. F. KEENAN, JR

2,013,829

STEAM GENERATOR

Filed July 7, 1931

4 Sheets-Sheet 1

Fig. 14.

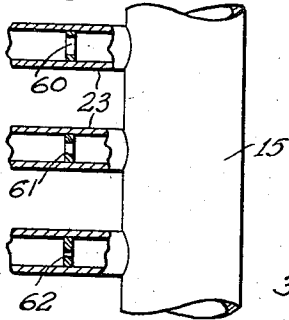


Fig. 1.

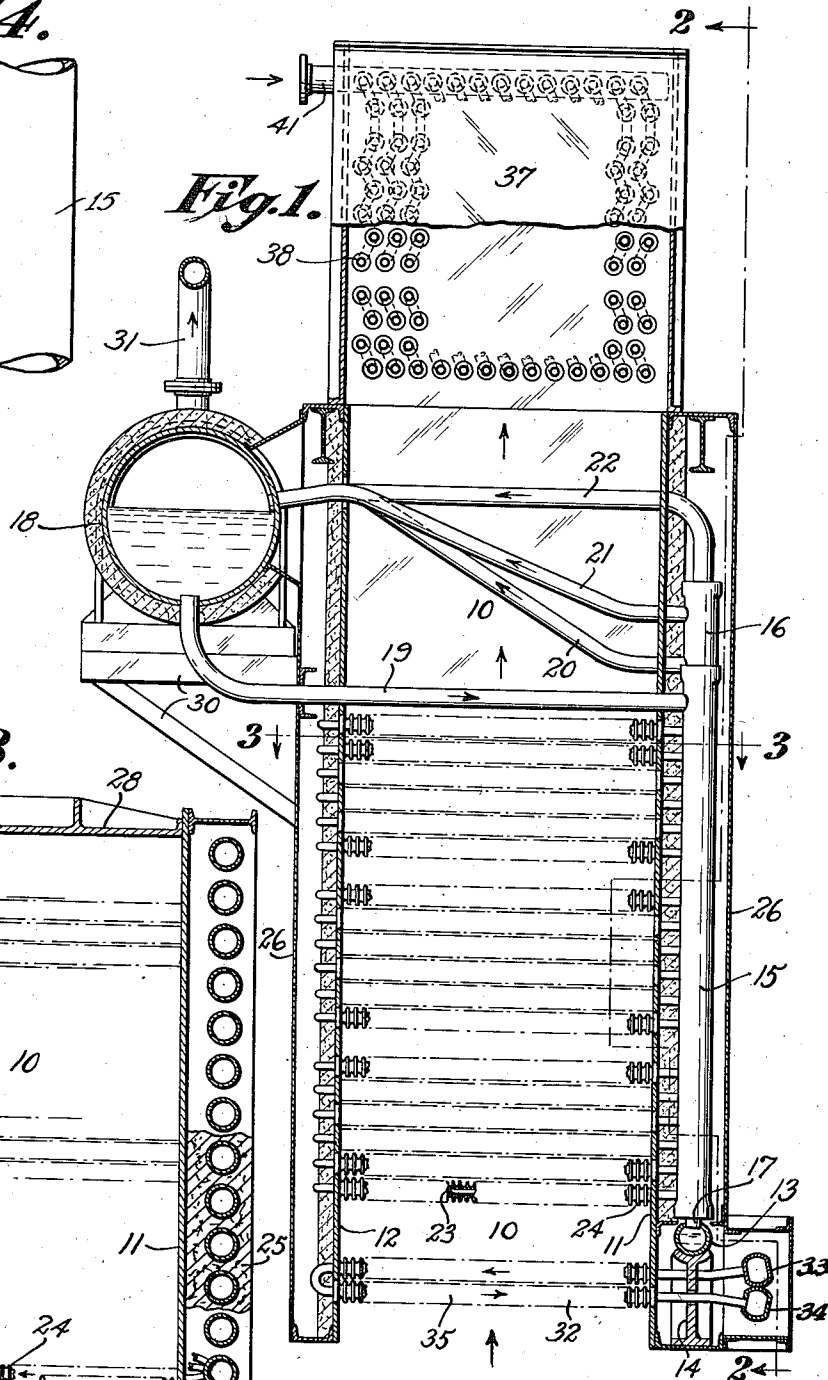
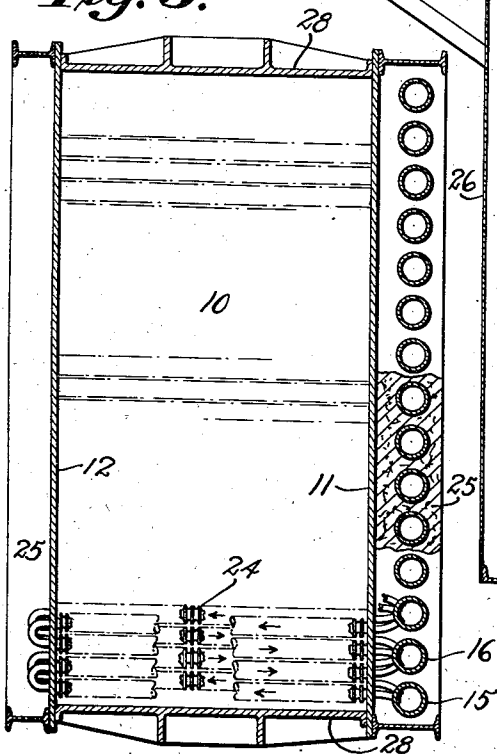


Fig. 3.



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4 Sheets-Sheet 2

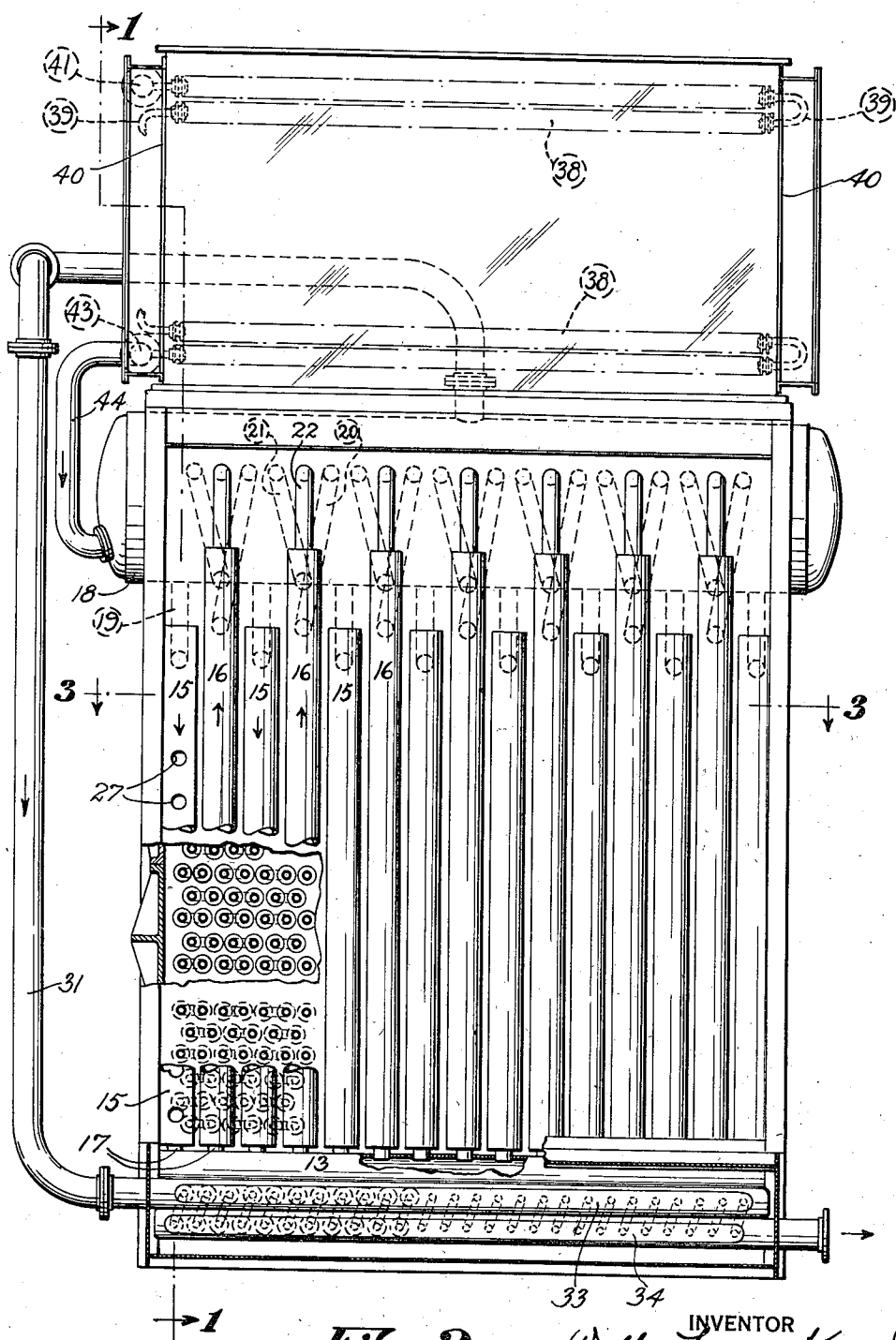


Fig. 2.

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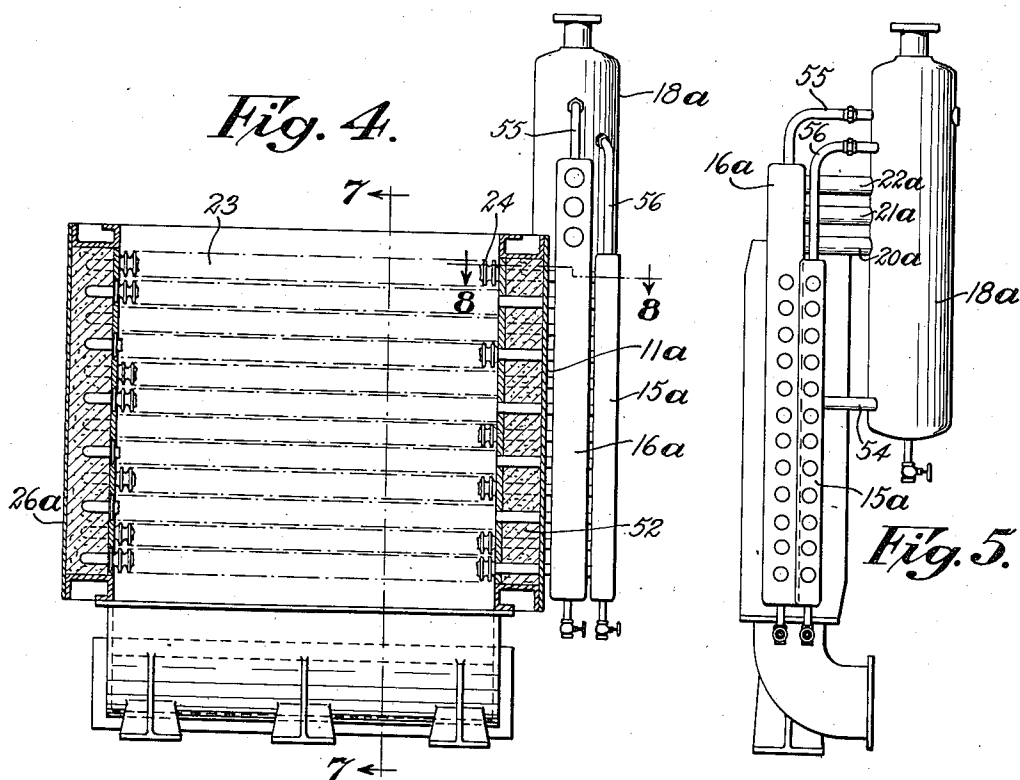
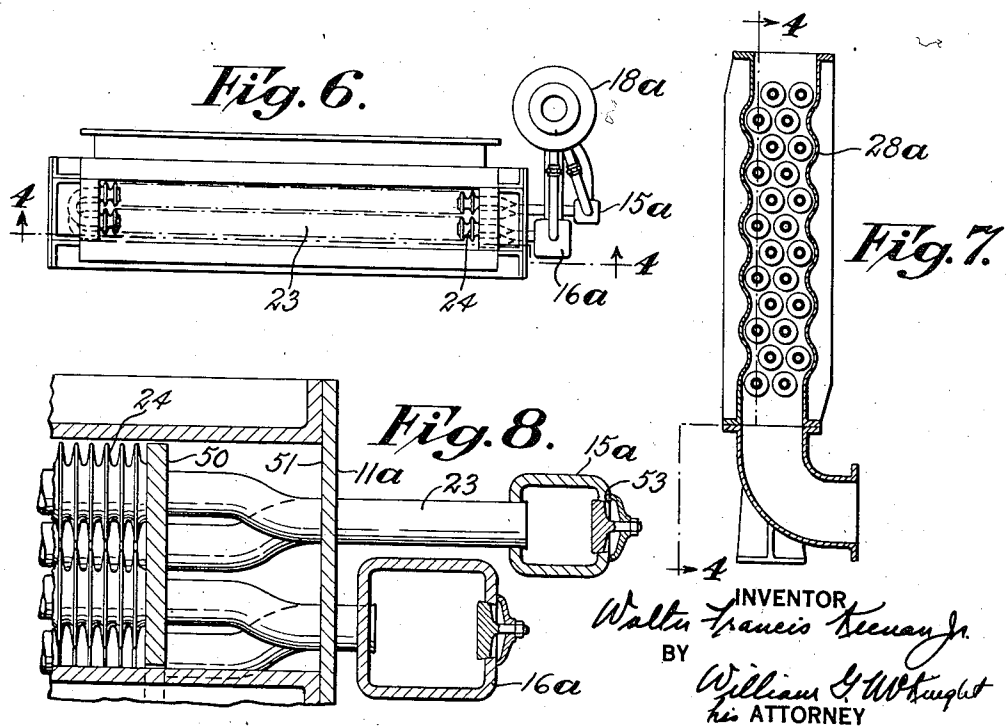
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STEAM GENERATOR

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4 Sheets-Sheet 3



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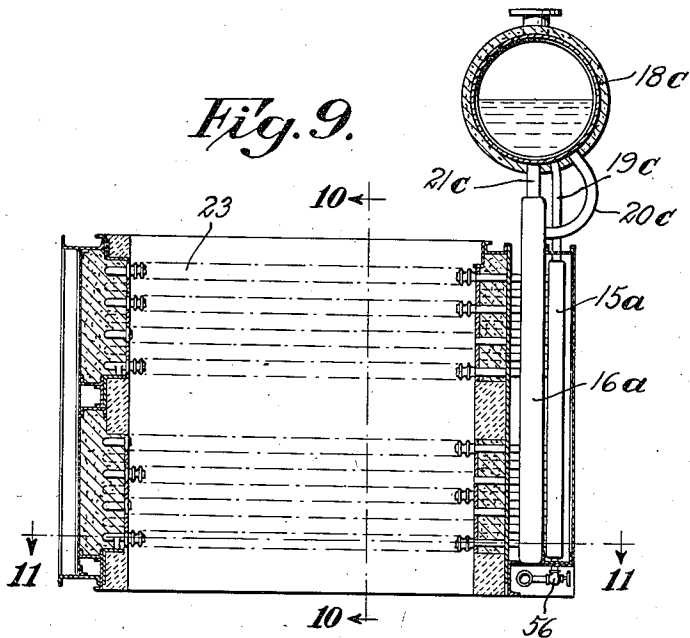
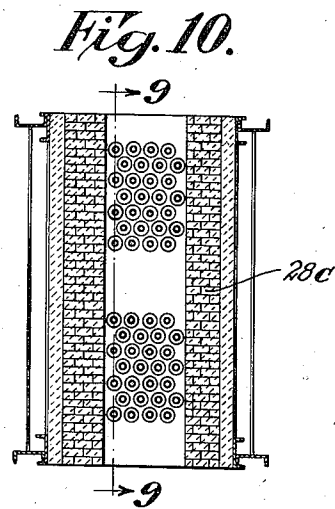
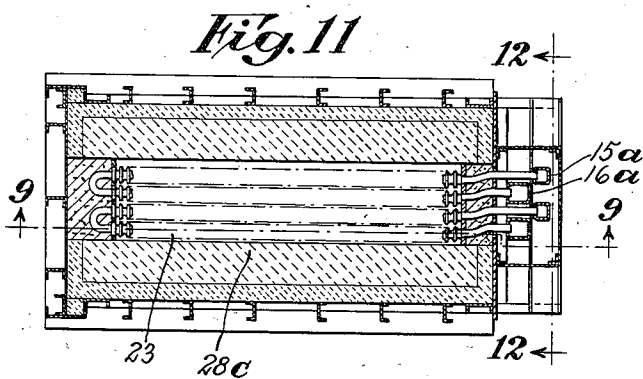
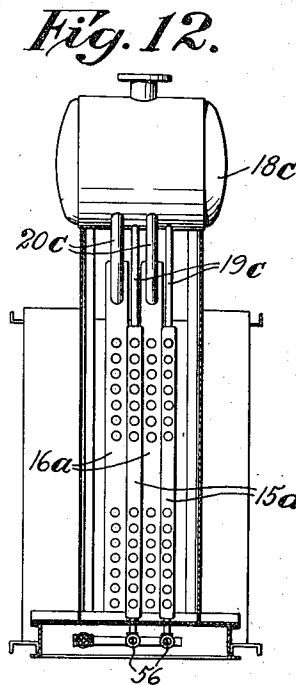
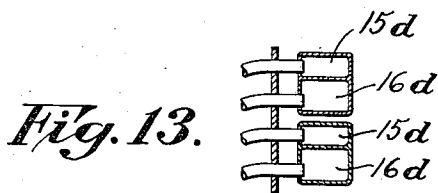
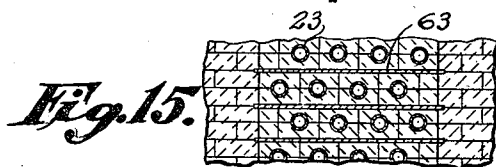
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STEAM GENERATOR

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,013,829

STEAM GENERATOR

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Application July 7, 1931, Serial No. 549,212
In Great Britain July 7, 1930

30 Claims. (Cl. 122-279)

My invention relates to steam generators, and has for its object to provide a novel steam generator which has a high steam generating capacity for a small size of structure, a generator in which a very efficient circulation of water takes place, one which is structurally easy to manufacture and easy to maintain in repair, and one which is capable of withstanding corrosive action of gases, has long life and has high efficiency at different ratings.

My invention relates particularly to steam generators in which the water passes transversely through the heating or combustion zone in two directions. As a general proposition it has been considered necessary in the past to obtain thermosiphon circulation in a boiler of this type by causing an upward flow of steam and water within the heating chamber. This has been most commonly accomplished by slightly inclining the tubes which are in direct contact with the products of combustion. Another method of accomplishing this has been to use a plurality of vertically spaced tubes connected in series by bends or headers. In either of these cases the designer has had in mind a vertical displacement of the water between the point of initial heating and the point of exit from the heating zone. In both these cases there has been a difference in elevation of the connections of the tube unit for any one individual flow between the inlet to the distributing header and the outlet to the collecting header.

In the first case, in which the tubes are inclined, it is apparent that parallelism of header walls is impractical in boilers of this type. For various types of work it is desirable to have what might be termed right angle construction in which the combustion chamber or heating chamber is a rectangular structure and the tubes are disposed at right angles to the walls. This is particularly true of boilers having extended surface members encasing the tubes. It has been proposed to obtain the structural advantages of right angle relationship of parts in a boiler by superposed rows of tubes connected in series. It will be evident that with this arrangement the intensity of circulation is in part determined by the number of vertical rows connected in series. There are certain structural limitations in this connection and, in a boiler of this type, particular care must be taken to avoid excessive resistance to circulation at relatively low capacity due to friction in the tubes.

In a boiler in accordance with the present invention I provide loop tubes with the inlet and

outlet of each tube at the same elevation. The tubes are disposed strictly horizontally. Consequently, the flow from the inlet of any U-tube to the outlet thereof, i. e., the flow back and forth across the combustion chamber or heating chamber, is in a definite horizontal plane. I depend for thermosiphon circulation entirely on the head differential in the outside connections. By this means I obviate all structural limitations as to number of superposed rows connected in series and at the same time obtain the structural advantages of what I have termed right angle construction.

The nature of my improved steam generator, its advantages and further objects of the invention will become apparent from a consideration of the following specification, taken in conjunction with the accompanying drawings, forming a part of this specification, which drawings show several embodiments of the invention, and of which:

Fig. 1 is essentially a vertical sectional view of one form of my improved steam generator taken on the line 1-1 of Fig. 2;

Fig. 2 is essentially a side view taken on the line 2-2 of Fig. 1;

Fig. 3 is a transverse sectional view taken on the lines 3-3 of Fig. 1 and Fig. 2;

Fig. 4 is a vertical cross-sectional view taken on the lines 4-4 of Fig. 6 and Fig. 7 showing another form of steam generator embodying the invention;

Fig. 5 is an end view of the structure shown in Fig. 4;

Fig. 6 is a top view of the structure shown in Fig. 4;

Fig. 7 is a transverse sectional view taken on the line 7-7 of Fig. 4;

Fig. 8 is an enlarged sectional view taken on the line 8-8 of Fig. 4;

Fig. 9 is a vertical sectional view taken on the lines 9-9 of Fig. 10 and Fig. 11 showing still another form of the invention;

Fig. 10 is a cross-sectional view taken on the line 10-10 of Fig. 9;

Fig. 11 is a horizontal sectional view taken on the line 11-11 of Fig. 9;

Fig. 12 is an end view of the structure shown in Figs. 9, 10, and 11;

Fig. 13 shows a modified header construction for use in my novel steam generator;

Fig. 14 illustrates a detail of construction; and Fig. 15 illustrates another detail.

The steam generator shown in Figs. 1, 2, and 3 comprises preferably four side walls which are dis-

posed in vertical planes and at right angles to each other so that the horizontal cross-section of the interior or gas space of the boiler is rectangular, as shown in Fig. 3. At the two sides of the combustion chamber 10 are vertically disposed flat steel or cast iron plates 11 and 12. These plates may be made up of sections of plate or may be of single pieces of plate. Plates 11 and 12 are punched or drilled at right angles thereto with tube holes.

Outside the gas passage or combustion or heating chamber 10 and to the outside of plate 11 and near the bottom of the generator setting is a horizontally disposed mud drum 13 carried by a cradle 14. Cradle 14 is of the general shape of an I-beam with the upper flange curved. Above mud drum 13 are vertically disposed headers 15 and 16. The headers 15 are shorter than headers 16. For convenience of description I term headers 15 distributor headers and headers 16 collector headers. The headers 15 are alternately disposed with respect to the headers 16, as shown in Fig. 2. Nipples 17 connect the lower end of each of the headers 15 and 16 with mud drum 13. The mud drum 13 serves as a support for the headers 15 and 16 by means of the nipples 17.

On the opposite side of the setting and on the outside of the wall 12 is a steam and water drum 18. The drum has its axis horizontally disposed and is near the upper part of the setting. Connected to the bottom of the drum is a series of water connections 19, which extend downwardly and then horizontally, as shown in Fig. 1, through the plates 12 and 11 at right angles thereto and connect into the upper ends of distributor headers 15. Three steam and water connections 20, 21 and 22 connect the upper ends of each collector header 16 with the steam and water drum 18. Connection 22 is connected to the top end of collector header 16; connection 21 is connected to collector header 16 a short distance below the top; and connection 20 is connected a still further distance below the top of the header 16. Both the water conducting tubes 19 and the steam and water connections 20, 21 and 22 may be connected to the drum 18 in staggered relation instead of in line as shown on the drawings.

Connecting headers 15 with adjacent headers 16 respectively are loop tubes 23. These loop tubes extend horizontally across the combustion chamber 10. One end of each loop tube 23 is expanded into a header 15 and the other end of the loop tube is expanded into a header 16. The connections of each loop tube 23 to the headers 15 and 16 are in the same horizontal plane. The bent ends of the loop tubes are horizontal and are outside the combustion chamber on the outside of the plate 12. Thus all the portions of the tubes which are in the combustion space are straight, and the bends and connections are protected by being outside the combustion space. If desired, separate curved connections may be used instead of the integral bends. As shown in Fig. 2, the tubes 23 are arranged in vertical staggered relation. This is also shown in Fig. 3. This affords a tortuous path for the products of combustion upwardly through the combustion chamber, the general line of flow being indicated by the arrows.

The tubes 23 are encased in surrounding material, preferably cast iron members 24 of the type known as gill rings or fins. These may be made up in groups or singly, and are preferably shrunk on the tubes. It will be seen that all the portions of the tubes within the combustion space are or may be covered with this cast iron extended sur-

face material. The tube holes in the plates are large enough to accommodate the tubes with the fins assembled thereon, the tubes being inserted into the setting from the left as shown in Fig. 1.

Insulating material 25 may be inserted in suitable insulation casings 26 around the tube ends outside the plates 11 and 12. The headers 15 and 16 are provided with suitable access holes 27 for expanding the tubes 23 thereinto. At the ends of the combustion chamber 10 are provided cast iron members 28 which may be ribbed, as shown, and which may be riveted or bolted to the plates 11 and 12. The steam and water drum is suitably supported by a bracket 29.

Steam is withdrawn from the steam and water drum 18 through pipe 31 and is conducted to a superheater 32 comprising headers 33 and 34, to which are connected superheater tubes 35 of the same general construction as the boiler tubes 23.

If the flow of gases is upwardly through the generator, the superheater is placed at the bottom as shown. Should the flow of gases be the other way, the superheater would be placed in the hot zone of the products of combustion.

Above the boiler section is an economizer 37. The particular economizer I have shown includes tubes extending horizontally and transversely of the boiler setting in the opposite direction to that of the tubes 23. The economizer tubes 38 are connected in series, row by row, by connections 39 outside the plates 40 forming the gas passage. Feed water is admitted to the inlet header 41 and is distributed to the tubes of the upper row and thence flows, row by row, to the header 43, whence the feed water flows by pipe 44 into the steam and water drum 18. The economizer tubes are likewise encased in extended surface cast iron members.

In the operation of the above described steam generator, water flows from the steam and water drum through pipes 19 and into the various distributor headers 15. The water flows downwardly in headers 15 and is distributed to the tubes 23. The water flows through tubes 23, across the combustion chamber, through the bends outside the plates 12 and back through the other branches of the tubes 23 across the combustion chamber to the collector headers 16. Steam and water rise through the headers 16 and are delivered to the steam and water drum through connections 20, 21 and 22. The heating of the tubes 23 causes the formation of steam.

Flow of the heated fluid across the heating chamber 10 is strictly horizontal. The flow is produced due to the difference in heads in the distributor headers and the collector headers, respectively. Each distributor header contains only or substantially only water. Each collector header contains a considerable proportion by volume of steam. Consequently the columns of fluid in the distributor headers are heavier than the fluid columns in the collector headers. This produces circulation downwardly in the distributor headers and upwardly in the collector headers. This induces the circulation in the loop tubes 23 due to the pressure differential between the inlet and outlet of each loop tube due to the head differential. It will be seen that the vertical directional effect for producing circulation is not within the heating or combustion chamber, but is outside the same and that the size of the tubes 23 does not affect the rate of circulation if the size is not so small as to give high friction loss. I contemplate using tubes of 2 inches or more in diameter, though it is to be understood that this statement

is made for illustrative purposes only and not by way of limitation.

With this construction the boiler may be built up to a considerable height; that is, the construction becomes less dependent on height than previous constructions of the same type having vertically spaced tubes in series.

It will be seen that the steam connection to the drum through pipes 20, 21 and 22 is of greater cross-sectional flow area than the water connection through pipes 19. Also pipes 19 are connected at the bottom of the drum whereas the pipes 20, 21 and 22 are connected at a higher level and preferably above the liquid level. The size, shape and position of these connections assure circulation in the manner above stated. Conduits 19, due to their relative restricted size, tend to prevent flow of steam upwardly through the distributor headers and thus insure the correct direction of flow.

With the above described construction, a maximum heating surface can be provided in a minimum space. The structure is compact. Tube replacement is easy since any loop tube can readily be withdrawn individually from the side opposite the headers. It is not necessary to enter the heating chamber to alter any of the parts. All the tube joints are outside the heating chamber. And the construction particularly lends itself to a most efficient utilization of fins, gill rings or the like.

It may be desirable to place restrictions at the inlets of the loop tubes in some constructions in order to ensure flow in the right direction and these restrictions may be of different cross-section, smaller as the tubes are farther down, to compensate for differences in flow-producing head as shown at 60, 61 and 62 in Fig. 14.

The steam generator shown in Figs. 4 to 8 inclusive is in general similar to the steam generator of Figs. 1 to 3. The tubes 23 are encased in extended surface members 24, preferably of cast iron, and which are corrosion-resisting. The tubes are so close that the fins 24 almost touch each other, thus giving high gas velocity. This form includes only one vertically disposed distributor header 15a and one vertically disposed collector header 16a. The distributor and collector headers are of rectangular cross-section and the collector header may be of greater cross-sectional area than the distributor header. The headers are disposed adjacent to and outside the wall 11a. The tubes are staggered as shown in Fig. 7 and the side plates 28a are made of corrugated cast iron in order to provide a sinuous passageway to conform to the staggered relation of the tubes and to avoid relatively large gas spaces between tubes and to give high gas velocity. This arrangement, including corrugated side plates close to the tubes, is advantageous for such applications as treatment of exhaust gases of Diesel engines. In will be noted that the corrugation of the side plates prevents straight or streamline flow adjacent any side wall and thereby increases the effectiveness of such a device when used for muffling purposes. In this arrangement the gases are caused to have sinuous flow transversely as well as being restricted and expanded in the general line of flow whereby good muffling effect can be obtained.

Wall structure 11a is a double wall comprising an inner wall 50 and an outer wall 51. These walls are parallel and spaced somewhat from each other, the intermediate space being preferably filled with insulating material 52. Wall 50 is

preferably made of cast iron or other corrosion-resistant material since it is directly subjected to the heat of the heating chamber. Since the tubes are staggered and since it is desirable for certain purposes that the tubes are connected to the headers in alignment, the tubes must be bent. If the tubes are bent inside the heating chamber, it is difficult to surround the tubes with extended surface members without the provision of special members or special manufacture. If the bends are outside the heating chamber and between the wall structure 11a and the header, it is difficult to expand the tube into the wall structure 11a, particularly after the apparatus is assembled. I therefore have provided the double wall in order to be able to use one kind of members for encasing the tubes and at the same time entirely surrounding the tubes in the heating chamber with the extended surface members, while permitting expanding of the tubes into the wall after assembly. The tubes are bent between the two plates of the double wall so that they pass at right angles both through the inner plate 50 and the outer plate 51. Hand holes 53 provided with suitable hand hole covers are provided opposite the tubes in the headers 15a and 16a. It will be seen that the portions of the tubes between the wall structure 11a and the headers are straight. Hence, an expanding tool can be inserted through the hand holes for expanding the tubes into the wall structure 11a whereby gas tightness is obtained. This is particularly important in connection with certain corrosive gases. The space between the plates is preferably filled with insulation material or refractory whereby the uncovered portions of the tubes are protected from the gases both by the plate 50 which is, in effect, a baffle plate, and the insulating material. The loop ends of the tubes, as in the case of the previously described embodiment, extend through the opposite wall and are encased in insulating material within a gas tight enclosure 26a. It will be seen that this steam generator can readily be made gas tight because the wall corners can be readily made gas tight and the only other places needing attention are the places where the tubes pass through the wall and the arrangement herein disclosed facilitates the expanding of these tubes into the wall to give gas tightness. Besides having the advantages above described, this construction facilitates the staggering of the tubes in the heating chamber, thereby improving heat absorption. It will be seen that only two forms of loop tubes are necessary, and it will be obvious that by suitably placing the headers it is possible to use but one form of loop tube construction in which adjacent loop tubes are simply reversed as to position. For purposes of replacement, with either arrangement only one form of loop tube is necessary, the end of one branch being cut to facilitate application to header construction of the type shown in Fig. 8.

The walls or plates through which the tubes pass and which are directly contacted by the heating gases, may be made up of plate sections individually fitted onto the loops.

In this embodiment, the drum 18a is disposed vertically. Water passes from the drum through connection 54 to the header 15a. The water passes through the tubes 23 and into header 16a and thence through connections 20a, 21a, 22a and 55 to the steam and water drum. A connection 56 is provided to vent any vapor or gas from the distributor header 15a to the steam and water drum.

This embodiment includes the characteristic

feature of the invention in that the tubes are horizontal and the ends thereof are connected to the distributor and collector headers at the same elevation. This embodiment is of the right angle construction above described. The flow of gases may be either upwardly or downwardly. A minimum gas passage has been provided, thus giving a high velocity of flow of gas which is advantageous for heat transmission and for preventing deposits on the heat absorbing surfaces.

In Figs. 9 to 12 is shown a steam generator which is particularly applicable to heating by certain waste heat gases. Vertical headers 15a and 16a are shown which are similar to those of the last described embodiment. The steam and water drum 18c is placed immediately above and only a short distance above the headers 15a and 16a. Short direct connections 19c, 20c and 21c connect the steam and water drum with the headers. These short connections and the position of the steam and water drum directly above the headers insure free circulation. This arrangement obviates extending any bare tubes through the heating space as in the structure shown in Fig. 1, the avoidance of bare tubes in the heating chamber being particularly advantageous with certain corrosive waste gases. It will be noted that the downcomer connection 19c is of smaller cross-sectional area than the combined cross-sectional area of the upcomer connections 20c and 21c.

Blow-off connections 55 are connected to each of the headers 15a providing a maximum cleaning effect. The side walls 28c in this case are made of refractory and may be curved to increase the velocity of the heating gases. Again in this embodiment the characteristic of the invention is present, in that the point of entry of the heated fluid into the heating space and the point of exit thereof are at the same level.

In the embodiments of the invention where a double wall is used and the tubes are bent between the wall plates, the protection may be afforded as shown in Fig. 15 by refractory members held on metal pieces 53 bridging the various loop tubes or supported on the side walls. This facilitates removal and replacement of tubes since refractory so supported will not fall when any tube is removed and will not be struck by a tube being reinserted. Such metal member may be in the form of an angle member with a base portion for supporting the refractory and a front portion to the fire side for protecting the refractory.

In Fig. 13 the distributor headers 15d and the collector headers 16d are combined, as shown, into units each comprising one distributor header and one collecting header.

It will be understood that the invention is capable of further modifications and that I am not to be limited to the structures shown and described. For instance, in certain cases it may be possible to extend the collector and distributor headers upwardly and eliminate the steam and water drum.

What I claim is:

1. A steam generator comprising wall structure enclosing a heating chamber, said wall structure including a vertical wall, a collector header outside said chamber and adjacent said vertical wall, a distributor header outside said chamber and adjacent said vertical wall, a horizontally extending loop tube extending within said chamber and passing through said vertical wall at right angles thereto, one end of said tube being connected to said distributor header and the other end being connected to said collector header, the connections of the tube to the headers being at the same

elevation, and extended surface members surrounding said tube in said chamber, the portions of said tube between the headers and said vertical wall being straight and the tube being expanded into said wall.

2. A steam generator comprising vertically disposed walls enclosing a heating chamber, a series of vertically disposed distributor headers outside said chamber, a series of vertically disposed collector headers outside said chamber, the distributor headers and the collector headers being alternately disposed, horizontally extending loop tubes extending within said heating chamber and connecting each distributor header with each collector header at the same elevation, a steam and water drum, connections from the steam and water drum to the distributor headers, and connections between the collector headers and the steam and water drum providing thermosiphon flow.

3. A steam generator comprising vertically disposed walls enclosing a heating chamber, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being alternately disposed, horizontally extending loop tubes extending within said heating chamber and connecting each distributor header with each collector header at the same elevation, a steam and water drum, open connections from the steam and water drum to the upper portions of the distributor headers, and open connections between the upper portions of the collector headers and the steam and water drum.

4. A steam generator comprising vertically disposed walls forming a setting and enclosing a heating chamber, a series of vertically disposed distributor headers outside said chamber, a series of vertically disposed collector headers outside said chamber, the distributor headers and the collector headers being adjacent and alternately disposed, horizontally extending loop tubes connecting each distributor header with each collector header at the same elevation and extending through walls of the setting, a steam and water drum, connections from the steam and water drum to the distributor headers, and connections between the collector headers and the steam and water drum providing thermosiphon flow.

5. A steam generator comprising vertically disposed walls forming a setting and enclosing a heating chamber, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being adjacent and alternately disposed, horizontally extending loop tubes connecting each distributor header with each collector header at the same elevation and extending through walls of the setting and being looped outside one of the walls of the setting and connected to the headers outside another wall, a steam and water drum, connections from the steam and water drum to the distributor headers, and connections between the collector headers and the steam and water drum.

6. A steam generator comprising vertically disposed walls enclosing a heating chamber, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being alternately disposed, horizontally extending tubes extending within said heating chamber and each connecting a distributor header with a collector header at the same elevation, a steam and water drum, open connections from the steam and water

drum to the distributor headers, and open connections between the collector headers and the steam and water drum.

7. A steam generator comprising vertically disposed walls enclosing a heating chamber, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being alternately disposed, horizontally extending loop tubes extending within said heating chamber and connecting each distributor header with each collector header at the same elevation, extended surface corrosion-resisting material on said tubes, a steam and water drum, open connections from the steam and water drum to the upper portions of the distributor headers, and open connections between the upper portions of the collector headers and the steam and water drum.

8. A steam generator comprising vertically disposed walls enclosing a heating chamber, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being adjacent and alternately disposed, horizontally disposed loop tubes connecting each distributor header with each collector header at the same elevation and having the loop bends thereof horizontal and situated outside the heating chamber at the opposite side of the generator to the distributor and collector headers, a steam and water drum, water connections from the steam and water drum to the distributor headers, and steam and water connections between the collector headers and the steam and water drum, whereby thermosiphon flow is produced due to head differential outside the heating chamber.

9. A steam generator comprising wall structure enclosing a heating chamber, said wall structure including a vertical wall, a collector header outside said chamber and adjacent said vertical wall, a distributor header outside said chamber and adjacent said vertical wall, a horizontally extending loop tube extending within said chamber and passing through said vertical wall at right angles thereto, one end of said tube being connected to said distributor header and the other end being connected to said collector header, said wall structure including an inner wall parallel to and spaced from said vertical wall, said tube passing at right angles through said inner wall and being bent between said walls, the portions of said tube between the headers and said first-mentioned wall being straight, and said tube being expanded in said first-mentioned wall.

10. A steam generator comprising wall structure enclosing a heating chamber, said wall structure including a vertical wall, a collector header outside said chamber and adjacent said vertical wall, a distributor header outside said chamber and adjacent said vertical wall, a horizontally extending loop tube extending within said chamber and passing through said vertical wall at right angles thereto, one end of said tube being connected to said distributor header and the other end being connected to said collector header, the connections of the tube to the headers being at the same elevation, said wall structure including an inner wall parallel to and spaced from said vertical wall, said tube passing at right angles through said inner wall and being bent between said walls, the portions of said tube between the headers and said first-mentioned wall being straight, and said tube being expanded in said first-mentioned wall.

11. A steam generator comprising wall struc-

ture enclosing a heating chamber, said wall structure including a vertical wall, a collector header outside said chamber and adjacent said vertical wall, a distributor header outside said chamber and adjacent said vertical wall, a horizontally extending loop tube extending within said chamber and passing through said vertical wall at right angles thereto, one end of said tube being connected to said distributor header and the other end being connected to said collector header, said wall structure including an inner wall parallel to and spaced from said vertical wall, said tube passing at right angles through said inner wall and being bent between said walls, the portions of said tube between the headers and said first-mentioned wall being straight, said tube being expanded in said first-mentioned wall, and protective material between said first-mentioned wall and said inner wall.

12. A steam generator comprising vertically disposed walls enclosing a heating chamber, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being alternately disposed and the collector headers having their upper ends at a higher level than the upper ends of the distributor headers, horizontally extending loop tubes extending within said heating chamber and connecting each distributor header with each collector header at the same elevation, extended surface corrosion-resisting material on said tubes, a steam and water drum, connections from the steam and water drum to the upper portions of the distributor headers, and connections between the upper portions of the collector headers and the steam and water drum.

13. A steam generator comprising vertically disposed walls enclosing a heating chamber, a horizontal drum at the lower part of the steam generator outside the heating chamber and adjacent one of the walls, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being adjacent and alternately disposed, nipples connecting said headers with said horizontal drum, horizontally disposed loop tubes connecting each distributor header with each collector header at the same elevation and having the loop bends thereof horizontal and situated outside the heating chamber at the opposite side of the generator to the distributor and collector headers, a steam and water drum, water connections from the steam and water drum to the distributor headers, and steam and water connections between the collector headers and the steam and water drum.

14. A steam generator comprising vertically disposed walls disposed at right angles and forming a setting and enclosing a heating chamber of rectangular cross-section, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being outside the heating chamber on one side thereof and alternately disposed, horizontally extending loop tubes connecting each distributor header with each collector header at the same elevation and extending through opposite walls of the setting at right angles thereto and being looped outside one of the walls of the setting and connected to the headers outside the opposite wall, extended surface rings covering said tubes within the heating chamber, a steam and water drum, connections from the steam and water drum to the dis-

tributor headers, connections between the collector headers and the steam and water drum, a superheater comprising tubes passing through and at right angles to opposite walls of the setting, and extended surface rings covering said superheater tubes within said heating chamber.

15. A steam generator comprising vertically disposed walls disposed at right angles and forming a setting and enclosing a heating chamber of rectangular cross-section, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being outside the heating chamber on one side thereof and alternately disposed, horizontally extending loop tubes connecting each distributor header with each collector header at the same elevation and extending through opposite walls of the setting at right angles thereto and being looped outside one of the walls of the setting and connected to the headers outside the opposite wall, extended surface rings covering said tubes within the heating chamber, a steam and water drum, connections from the steam and water drum to the distributor headers, connections between the collector headers and the steam and water drum, a superheater comprising tubes passing through and at right angles to opposite walls of the setting, extended surface rings covering said superheater tubes within the heating chamber, an economizer comprising tubes passing through and at right angles to opposite walls of the setting, and extended surface rings covering said economizer tubes within the heating chamber.

16. A steam generator comprising wall structure enclosing a heating chamber, said wall structure including a vertical wall, a collector header outside said chamber and adjacent said vertical wall, a distributor header outside said chamber and adjacent said vertical wall, and a horizontally extending loop tube extending within said chamber and passing through said vertical wall at right angles thereto, one end of said tube being connected to said distributor header and the other end being connected to said collector header, said wall structure including an inner wall spaced from said vertical wall, said tube passing at right angles through said inner wall and being bent between said walls, the portions of said tube between the headers and said first-mentioned wall being straight.

17. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum, a connection from the collector header to said drum, and restrictions in the loop tubes adjacent the distributor header to cause the steam generated in said tubes to flow toward the collector headers.

18. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop

tube to said headers being at substantially the same elevation, restrictions in the loop tubes adjacent the distributor header to cause the steam generated in said tubes to flow toward the collector headers, a steam and water drum, a connection from the distributor header to said drum and a connection from the collector header to said drum to provide thermosiphon circulation from said drum through the distributor header, loop tubes, collector header and back to the drum.

19. A steam generator comprising a heating chamber, a series of vertically disposed distributor headers, a series of vertically disposed collector headers, the distributor headers and the collector headers being alternately disposed, horizontally extending loop tubes in the heating chamber and connecting each distributor header with each collector header at the same elevation, a steam and water drum, connections from the steam and water drum to the distributor headers, connections between the collector headers and the steam and water drum providing thermosiphon flow, and restrictions in the loop tubes adjacent the distributor headers to cause the steam generated in said tubes to flow toward the collector headers.

20. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum, a connection from the collector header to said drum, and restricting means causing the steam generated in said tubes to flow toward the collector headers.

21. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum and a connection from the collector header to said drum having a larger flow area than the connection from the distributor header to the drum.

22. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum and a connection from the collector header to said drum, the collector header having a larger flow area than the distributor header.

23. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending

within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum and a connection from the collector header to said drum having a larger flow area than the connection from the distributor header to the drum, the collector header having a larger flow area than the distributor header.

24. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum and a connection from the collector header to said drum above the normal water level in said drum, the latter connection having a larger flow area than the former.

25. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum, a connection from the collector header to said drum having a larger flow area than the connection from the distributor header to the drum, and restrictions in the loop tubes adjacent the distributor header to cause the steam generated in said tubes to flow toward the collector headers.

26. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, and means connecting the upper ends of the distributor and collector headers, the collector header having a larger flow area than the distributor header.

27. A steam generator comprising a heating chamber, a vertically disposed distributor head-

er, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube connected to the distributor header and the other end connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, restrictions in the loop tubes adjacent the distributor header to cause steam generated in the tubes to flow toward the collector header and means connecting the upper ends of the distributor and collector headers.

28. A steam generator comprising a heating chamber, a vertically disposed distributor header, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube directly connected to the distributor header and the other end directly connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum and a connection from the collector header to said drum, the arrangement providing thermosiphon circulation through the generator.

29. A steam generator comprising a heating chamber, a vertically disposed distributor header disposed outside the heating chamber, a vertically disposed collector header, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube directly connected to the distributor header and the other end directly connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum and a connection from the collector header to said drum, the arrangement providing thermosiphon circulation through the generator.

30. A steam generator comprising a heating chamber, a vertically disposed distributor header disposed outside the heating chamber, a vertically disposed collector header disposed outside the heating chamber, a plurality of horizontally disposed loop tubes extending within the heating chamber, each having one end of the tube directly connected to the distributor header and the other end directly connected to the collector header, the connections of the ends of each loop tube to said headers being at substantially the same elevation, a steam and water drum, a connection from the distributor header to said drum and a connection from the collector header to said drum, the arrangement providing thermo-siphon circulation through the generator.

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