May 7, 1935. M. H. KUHNER 2,000,138

STEAM GENERATOR

Filed July 3, 1933 4 Sheets-Sheet 1

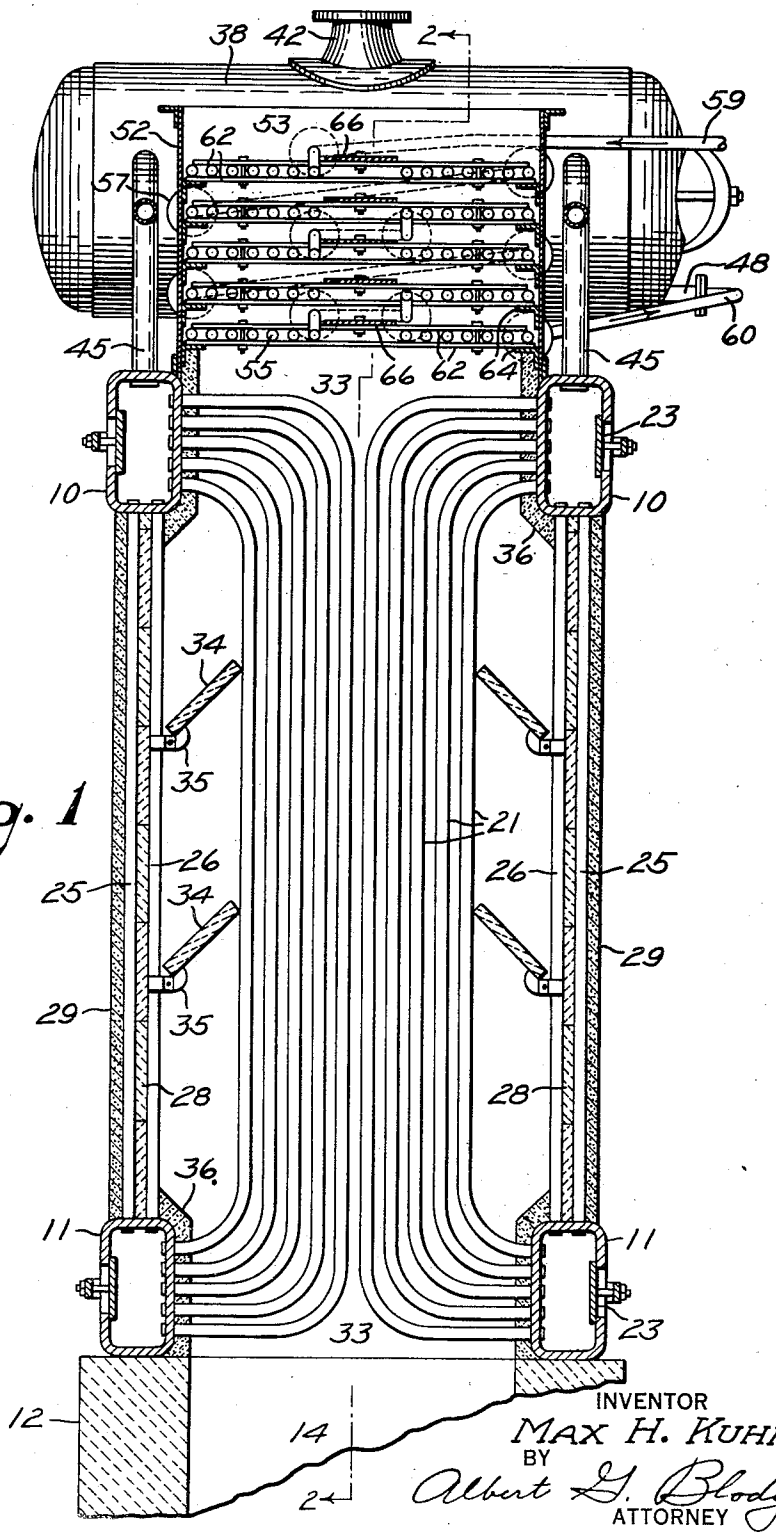

Fig. 1

INVENTOR
MAX H. KUHNER
BY
Albert G. Blodgett
ATTORNEY

May 7, 1935. M. H. KUHNER 2,000,138

STEAM GENERATOR

Filed July 3, 1933 4 Sheets-Sheet 2

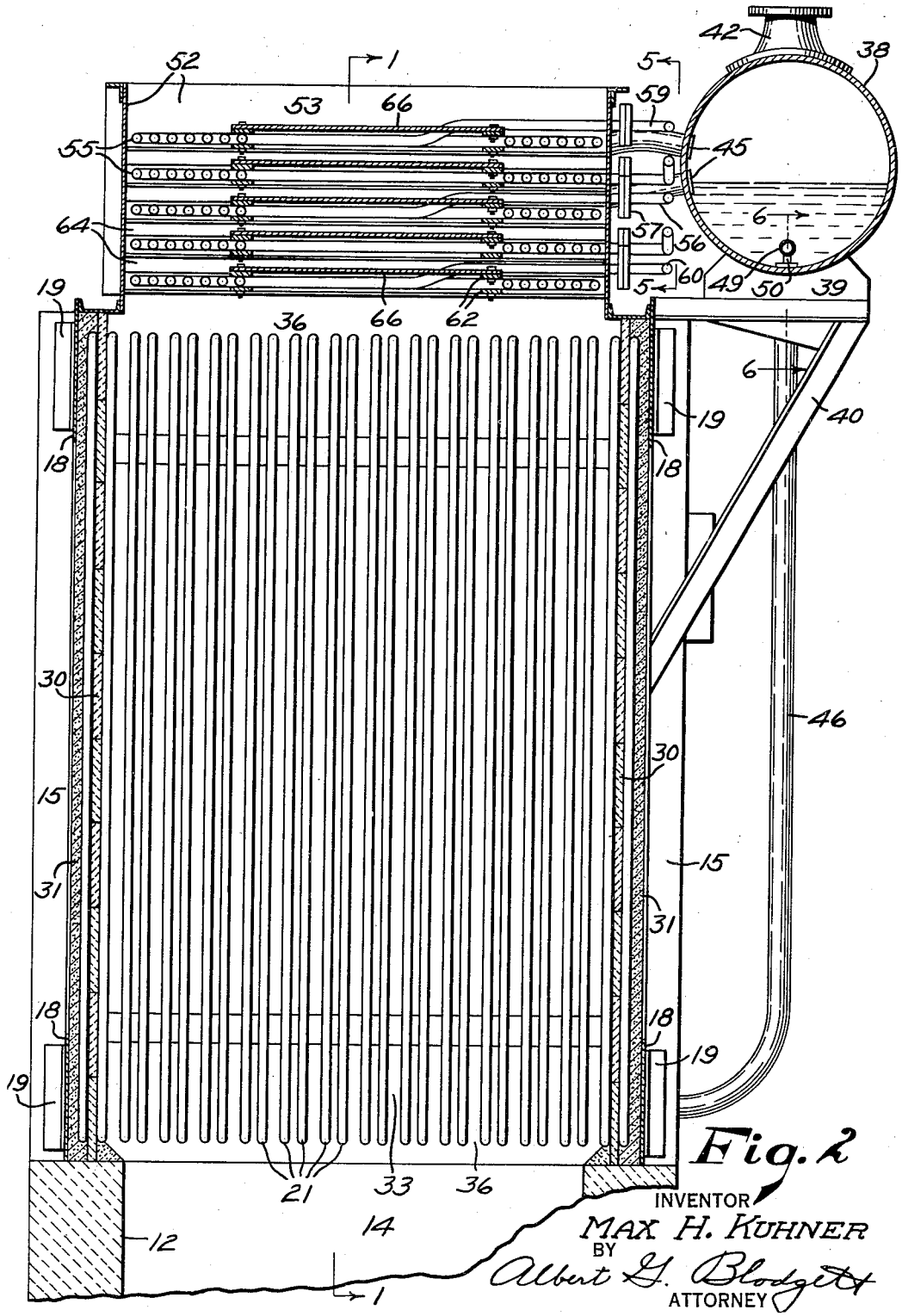

Fig. 2

INVENTOR
MAX H. KUHNER
BY
Albert G. Blodgett
ATTORNEY

May 7, 1935. M. H. KUHNER 2,000,138

STEAM GENERATOR

Filed July 3, 1933 4 Sheets-Sheet 3

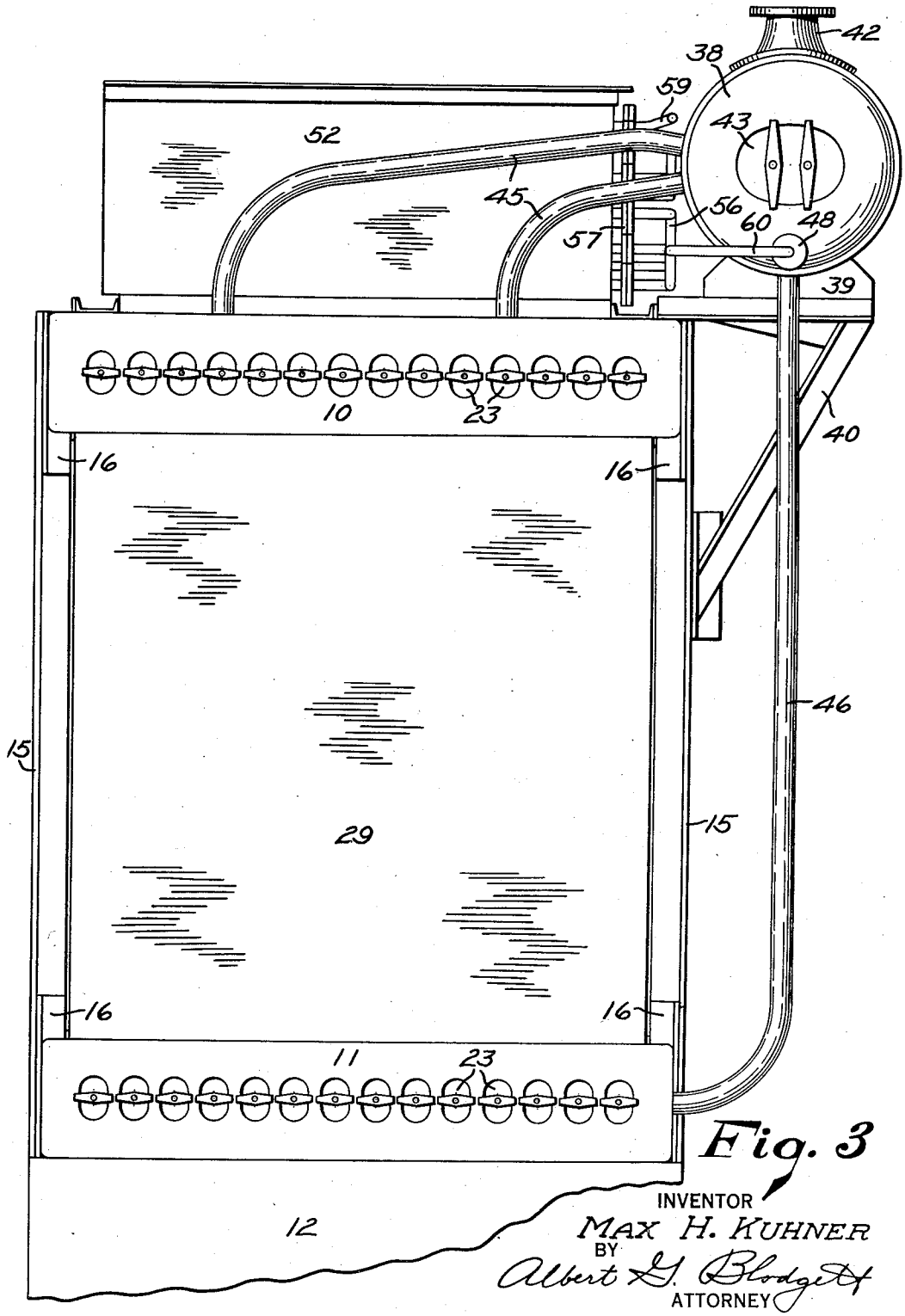

Fig. 3

INVENTOR
MAX H. KUHNER
BY
Albert G. Blodgett
ATTORNEY

May 7, 1935. M. H. KUHNER 2,000,138

STEAM GENERATOR

Filed July 3, 1933 4 Sheets-Sheet 4

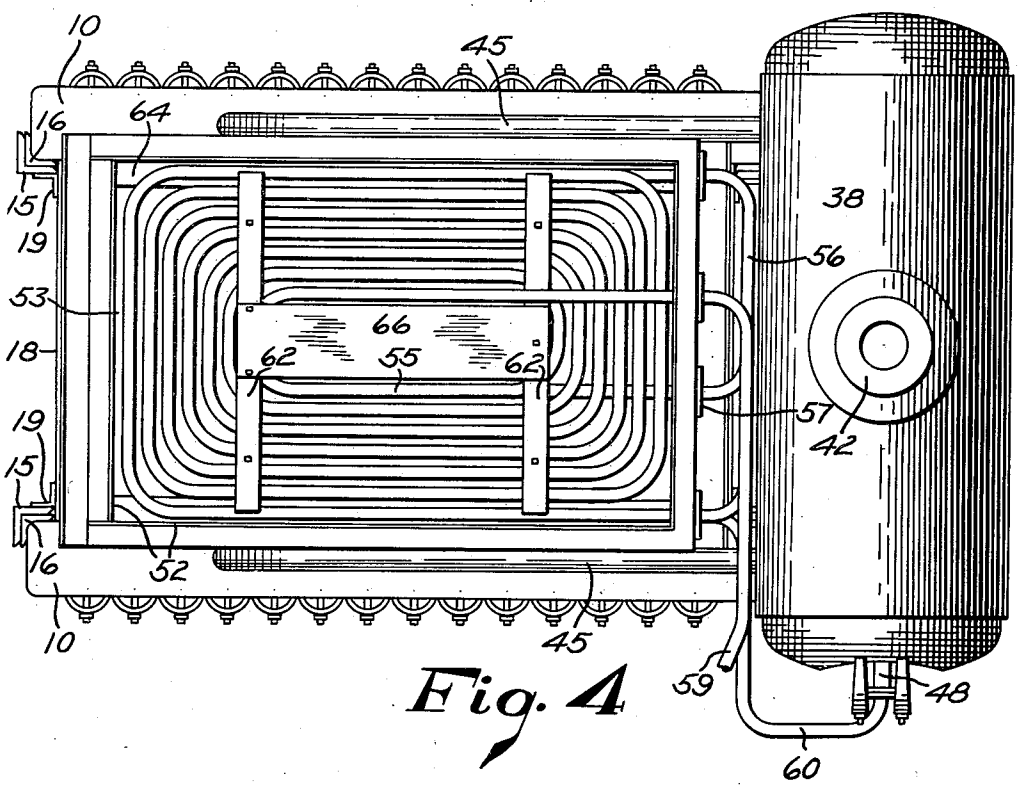

Fig. 4

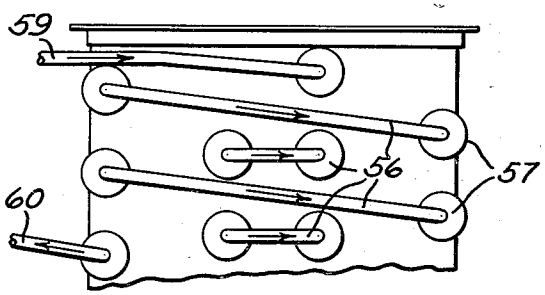

Fig. 5

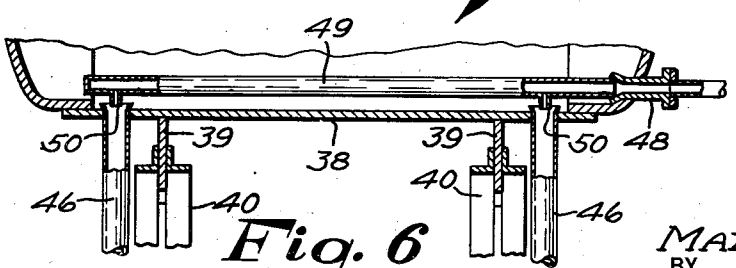

Fig. 6

INVENTOR
MAX H. KUHNER
BY
Albert G. Blodgett
ATTORNEY

Patented May 7, 1935 2,000,138

UNITED STATES PATENT OFFICE

2,000,138

STEAM GENERATOR

Max H. Kuhner, Worcester, Mass., assignor to Riley Stoker Corporation, Worcester, Mass., a corporation of Massachusetts

Application July 3, 1933, Serial No. 678,804

13 Claims. (Cl. 122—332)

This invention relates to steam generators, and more particularly to a steam generator of the water tube type adapted to be heated by means of waste gases, such as the exhaust gases from Diesel engines. It will be apparent, however, to those skilled in the art that the invention has great practical advantages irrespective of the source of the hot gases used therewith.

It is one object of the present invention to provide a steam generator which will be simple and inexpensive to manufacture, and which will ensure a continuous unrestricted circulation of the water and steam.

It is a further object of the invention to provide a steam generator having a large capacity in proportion to the space required, and particularly to so arrange the parts that a minimum of masonry work will be necessitated.

It is a further object of the invention to provide a steam generator which is readily accessible for cleaning or repairs.

It is a further object of the invention to provide an efficient steam generator which will absorb a large part of the heat from the gases flowing therethrough, even though these gases are supplied at a comparatively low temperature.

It is a further object of the invention to provide a steam generator which will have a low draft loss and hence will produce a comparatively small back pressure on the engines supplying gases thereto.

It is a further object of the invention to provide a steam generator which will serve as an efficient muffler to reduce to a minimum the noise from the exhaust of the engines supplying gases thereto.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

Referring to the drawings illustrating one embodiment of the invention, and in which like reference numerals indicate like parts,

Fig. 1 is a vertical transverse section through a steam generator, the section being taken on the line 1—1 of Fig. 2;

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

Fig. 3 is a side elevation of the steam generator;

Fig. 4 is a top plan view of the steam generator;

Fig. 5 is a fragmentary view on the line 5—5 of Fig. 2; and

Fig. 6 is a section on the line 6—6 of Fig. 2,

The embodiment illustrated in the drawings comprises two upper horizontal headers 10 and two lower horizontal headers 11, the four headers being parallel and arranged at the four corners of a vertical rectangle, as shown particularly in Fig. 1. The lower headers 11 rest upon walls 12 which define a passage 14 into which hot gases may be discharged from Diesel engines (not shown). The upper and lower headers are connected by four vertical angle iron columns 15 which are fastened to small angle irons 16 welded or otherwise secured to the ends of the headers. The headers are also tied together laterally by transverse vertical plates 18 fastened at each end to small angle irons 19 secured to the columns 15. The headers 10 and 11 are preferably rectangular in cross-section, and mounted with their long sides vertical.

Within the central portion of the rectangular space defined by the headers I provide a group of vertical tubes 21 having their upper and lower ends connected to the upper and lower headers respectively. These tubes are arranged in transverse rows, and the ends of the tubes are bent laterally in the planes of the rows and connected to the vertical inner walls of the headers. Half of the tubes are connected to the headers at one side and half to the headers at the other side. Alternately wide and narrow spaces are provided between the tube rows, as shown in Fig. 2, in order to facilitate the removal and replacement of individual tubes. Removable handhole plates 23 are provided in the outer side walls of the headers 10 and 11, to allow access to the insides of the tubes for cleaning or replacement purposes.

Between each upper header 10 and the corresponding lower header 11 I provide a longitudinal row of vertical downcomer tubes 25 (Fig. 1) and a longitudinal row of vertical tubes 26, the tubes 26 being spaced inwardly a short distance from the tubes 25. Between the tube rows 25 and 26 I provide a wall of refractory tiles 28 which are supported by the tubes. The downcomer tubes 25 and the tiles 28 are preferably covered on the outside by a layer of insulating material 29 applied in plastic form. Between each extreme transverse row of tubes 21 and the row adjacent thereto I provide a wall of refractory tiles 30 (Fig. 2) which are supported by the tubes. These tiles 30 and the extreme rows of tubes 21 are preferably covered on the outside by a layer of insulating material 31 applied in plastic form. It will be apparent that this construction provides walls defining a vertical gas passage 33 above and in direct com-

munication with the passage 14. The tiles 28 and 30 prevent any substantial transfer of heat to the downcomer tubes, and at the same time the tiles are firmly supported and well protected from the heat by tubes on both sides. The insulation material 29 and 31 forms an air-tight covering and prevents any substantial radiation loss.

It will be noted from Fig. 1 that the tubes 21 are spaced laterally from the side walls of the gas passage. In order to direct the gases among the tubes, I provide a plurality of vertically spaced baffles 34 which extend between the side walls and the tubes. These baffles are formed of refractory tiles supported at their lower edges on brackets 35 secured to the tubes 26. The tiles 34 incline upwardly and inwardly, their upper edges resting against the tubes 21. With this construction the cross-sectional area of the gas passage 33 alternately increases and decreases, so that a pronounced muffling effect is produced in the case of Diesel engine exhaust gases. The headers 10 and 11 are preferably protected from the hot gases by refractory material 36 applied in plastic form.

A transverse horizontal cylindrical drum 38 is located above the upper headers 10 and offset from the gas passage 33 in a direction longitudinal of the headers. This drum is supported in saddles 39 carried by brackets 40 which are mounted on two of the columns 15. This drum is provided with a steam discharge nozzle 42 and a man hole cover 43. Steam is delivered to the drum from the upper headers 10 through upcomer tubes 45. In the drawings I have shown two of these tubes curving upwardly and rearwardly from each header 10 to the drum. These tubes 45 are preferably larger in diameter than the tubes 21, so that they will have ample capacity to deliver all of the steam generated. Two tubes 46 lead downwardly from the bottom of the drum 38 and are connected to the rear ends of the lower headers 11 to complete a circulation path through the drum. The feed water is delivered to the drum through a nozzle 48 at one end thereof, and in order to aid the circulation through the tubes 46 I preferably discharge the feed water in jets into the upper ends of these tubes. For this purpose I provide a feed water distributing pipe 49 which connects with the nozzle 48 inside the drum and extends longitudinally of the drum directly above the tubes 46. The pipe 49 is provided with a nozzle 50 above each tube 46 to direct water downwardly into the tube.

In order to increase the efficiency of the steam generator and reduce the gases to a lower temperature than is possible with the tubes 21 alone, I preferably utilize an economizer which is so arranged that it will heat the feed water and also assist in muffling the noise of the engine exhaust. For this purpose I have shown vertical walls 52, which may be of steel plate, arranged to form a gas passage 53 rectangular in cross-section and directly above and in communication with the passage 33. Within the passage 53 I provide a plurality of tube coils 55, five being shown, located one above another and each arranged in a horizontal plane. Each coil 55 is shaped generally as a rectangular spiral, the tubes extending parallel to the adjacent walls 52. The two ends of each coil extend rearwardly into the space between the passage 53 and the drum 38, and pipes 56 are provided in this space to connect the coils in series, flanged joints 57 being utilized between the pipes 56 and the tubes 55. Feed water is delivered into the uppermost coil 55 by means of a pipe 59, and after flowing through the coils successively it is delivered from the lowermost coil to the drum nozzle 48 by means of a pipe 60.

Each coil 55 is supported and held substantially rigid by means of two pairs of flat bars 62 extending transversely in contact with the upper and lower surfaces of the coil, the bars of each pair being bolted together. The lower bars 62 rest upon shelves formed by angle irons 64 fastened to the side walls 52 and extending parallel to the headers 10. With this construction it is possible to slide each coil separately out of the gas passage for inspection or replacement, after first removing the front wall of the gas passage and disconnecting the coil from the corresponding pipes 56.

In order to prevent the gases from flowing directly through the rectangular space at the center of each coil, I provide horizontal rectangular baffles 66, which may be of steel plate. These plates 66 are secured to the upper bars 62. Since these plates 66 are spaced apart vertically, they cause the upwardly flowing gases to expand and contract alternately, thus adding considerably to the muffling effect of the steam generator.

The operation of the invention will now be apparent from the above disclosure. Hot gases, such as the exhaust gases from Diesel engines, are delivered to the passage 14 and flow upwardly through the passage 33 in contact with the tubes 21 and thence through the passage 53 in contact with the tubes 55. Steam is generated in the tubes 21 and causes a continuous circulation of water upwardly in these tubes and downwardly in the tubes 25. The flow is also downward in the front and rear rows of the tubes 21, which are not exposed to heat. The steam which is delivered by the tubes 21 to the upper headers 10 flows upwardly through the tubes 45 to the drum 38, and thence outwardly through the nozzle 42 to a place of use. The feed water enters the economizer through the pipe 59 and flows through the coils 55 successively in a generally downward direction as opposed to the upward flow of the gases. The feed water after being heated in the coils 55 passes through the pipe 60 and nozzle 48 into the drum 38, and is discharged in jets from the nozzles 50 into the downcomer tubes 46. These tubes 46 deliver to the lower headers 11 not only the feed water but also any water which has been carried upwardly into the drum through the tubes 45 by the steam.

It will be clear from the above description that I have provided a steam generator having a main circulating system including the convection water tubes, and a secondary circulatory system including the steam and water drum which serves to receive the generated steam and to supply the feed water. The steam leaves the main circulating system as soon as it is formed, and the circulation is continuous and unrestricted. The construction is simple and inexpensive. Only one drum is required, and this is unexposed to hot gases. Because of the arrangement of the parts the steam generator is very compact, and very little masonry work is required at installation. The tiles forming the walls of the gas passage are well supported and cooled by the adjacent water tubes. All internal parts of the water circulating system are readily accessible for cleaning or repairs. The integral counterflow economizer reduces the exit gases to a low temperature and contributes appreciably to the efficiency of the steam generator. Since the tubes 21 are vertical and the gas flow is parallel to these tubes, the gases contact with substantially the entire area of the tubes. Furthermore the draft loss through

the steam generating tube bank is unusually small because of this parallel flow. In both the steam generating and economizer sections the gases are caused to expand and contract alternately, so that the noise from the engine exhaust is very effectively muffled. This is of great practical value in many installations.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, longitudinal walls extending between the upper and lower headers to define a vertical gas passage, a group of vertical tubes located within the gas passage and spaced laterally from said walls, the upper and lower ends of the tubes being bent laterally and connected to the upper and lower headers respectively, and a plurality of vertically spaced baffles extending between each wall and the tubes to direct gases among the tubes.

2. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, walls extending between the upper and lower headers to define a vertical gas passage, downcomer tubes connecting the upper and lower headers, a group of vertical tubes located within the central portion of the gas passage, the upper and lower ends of the vertical tubes being bent outwardly and connected to the upper and lower headers respectively, a horizontal drum located above the upper headers and offset from the gas passage, steam delivery tubes connecting the upper headers with the drum, and downcomer tubes connecting the drum with the lower headers.

3. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, a longitudinal row of downcomer tubes connecting each of the upper headers with the header therebeneath, refractory material associated with the downcomer tubes to form walls defining a vertical gas passage, a group of vertical tubes located within the central portion of the gas passage, the upper and lower ends of the vertical tubes being bent outwardly and connected to the upper and lower headers respectively, a transverse horizontal drum located above the upper headers and offset from the gas passage in a direction longitudinal of the headers, steam delivery tubes connecting the upper headers with the drum, and downcomer tubes connecting the drum with the lower headers.

4. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, a longitudinal row of downcomer tubes connecting each of the upper headers with the header therebeneath, refractory material associated with the downcomer tubes to form walls defining a vertical gas passage, a group of vertical tubes located within the gas passage, the upper and lower ends of the vertical tubes being connected to the upper and lower headers respectively, a transverse horizontal drum located above the upper headers and offset from the gas passage in a direction longitudinal of the headers, steam delivery tubes connecting the upper headers with the drum, downcomer tubes connecting the drum with the lower headers, walls defining an upward extension of the vertical gas passage, and an economizer located in the upward extension.

5. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, walls extending between the upper and lower headers to define a vertical gas passage, downcomer tubes connecting the upper and lower headers, a group of vertical tubes located within the gas passage and connected at their upper and lower ends to the upper and lower headers respectively, walls defining an upward extension of the gas passage, a plurality of coils of water tubes located in the said upward extension and vertically spaced from each other, each coil being in a substantially horizontal plane, means connecting the coils in series, and means to pass feed water through the coils in a generally downward direction.

6. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, walls extending between the upper and lower headers to define a vertical gas passage, downcomer tubes connecting the upper and lower headers, a group of vertical tubes within the gas passage and connected at their upper and lower ends to the upper and lower headers respectively, walls defining an upward extension of the gas passage, a plurality of coils of water tubes located in the said upward extension and vertically spaced from each other, each coil being shaped as a horizontal spiral having an open space at its central portion, a horizontal baffle plate closing the open space in each coil, means connecting the coils in series, and means to pass feed water through the coils in a generally downward direction.

7. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, walls extending between the upper and lower headers to define a vertical gas passage, downcomer tubes connecting the upper and lower headers, a group of vertical tubes within the gas passage and connected at their upper and lower ends to the upper and lower headers respectively, vertical walls defining an upward extension of the gas passage, said upward extension being rectangular in cross-section, a plurality of coils of water tubes located in the said upward extension and vertically spaced from each other, each coil being shaped generally as a rectangular spiral with the tubes extending parallel to the adjacent vertical wall, and means projecting inwardly from said vertical walls to support the coils.

8. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, each header being rectangular in cross-section and having its longer sides vertical, and a group of vertical tubes located within the central portion of said rectangle, the ends of the tubes being bent outwardly and connected to the inner vertical sides of the headers.

9. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, each header being rectangular in cross-section and having its longer sides vertical, walls extending between the upper and lower headers to define a vertical gas passage, and a group of vertical tubes located within the central portion of said gas passage, the ends of the tubes being bent outwardly and connected to the inner vertical sides of the headers.

10. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, each header being rectangular in cross-section and having its longer sides vertical, a row of downcomer tubes connecting the lower side of each upper header with the

upper side of the header therebeneath, and a group of vertical tubes located within the central portion of said rectangle, the tubes of said group having their ends bent outwardly and connected to the inner vertical sides of the headers.

11. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, each header being rectangular in cross section and having its longer sides vertical, a row of downcomer tubes connecting the lower side of each upper header with the upper side of the header therebeneath, refractory material supported by the downcomer tubes and arranged to form walls defining a gas passage, and a group of vertical tubes located within the central portion of said gas passage, the tubes of said group having their ends bent outwardly and connected to the inner vertical sides of the headers.

12. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, walls extending between the upper and lower headers to define a vertical gas passage, a group of vertical tubes located within the gas passage and spaced laterally from said walls, the upper and lower ends of the tubes being bent outwardly and connected to the adjacent headers, and baffles extending between the walls and the tubes to direct gases among the tubes.

13. A steam generator comprising four parallel horizontal headers arranged at the four corners of a vertical rectangle, walls extending between the upper and lower headers to form a vertical gas passage, downcomers connecting the upper headers to the lower headers, a group of vertical tubes located within the gas passage, the ends of the tubes being connected to the adjacent headers, a horizontal drum located above the upper headers and offset from the gas passage, steam delivery tubes connecting the upper headers with the drum, downcomers connecting the drum with the lower headers, walls defining an upward extension of the vertical gas passage, and an economizer located in the upward extension.

MAX H. KUHNER.