

Dec. 22, 1942.

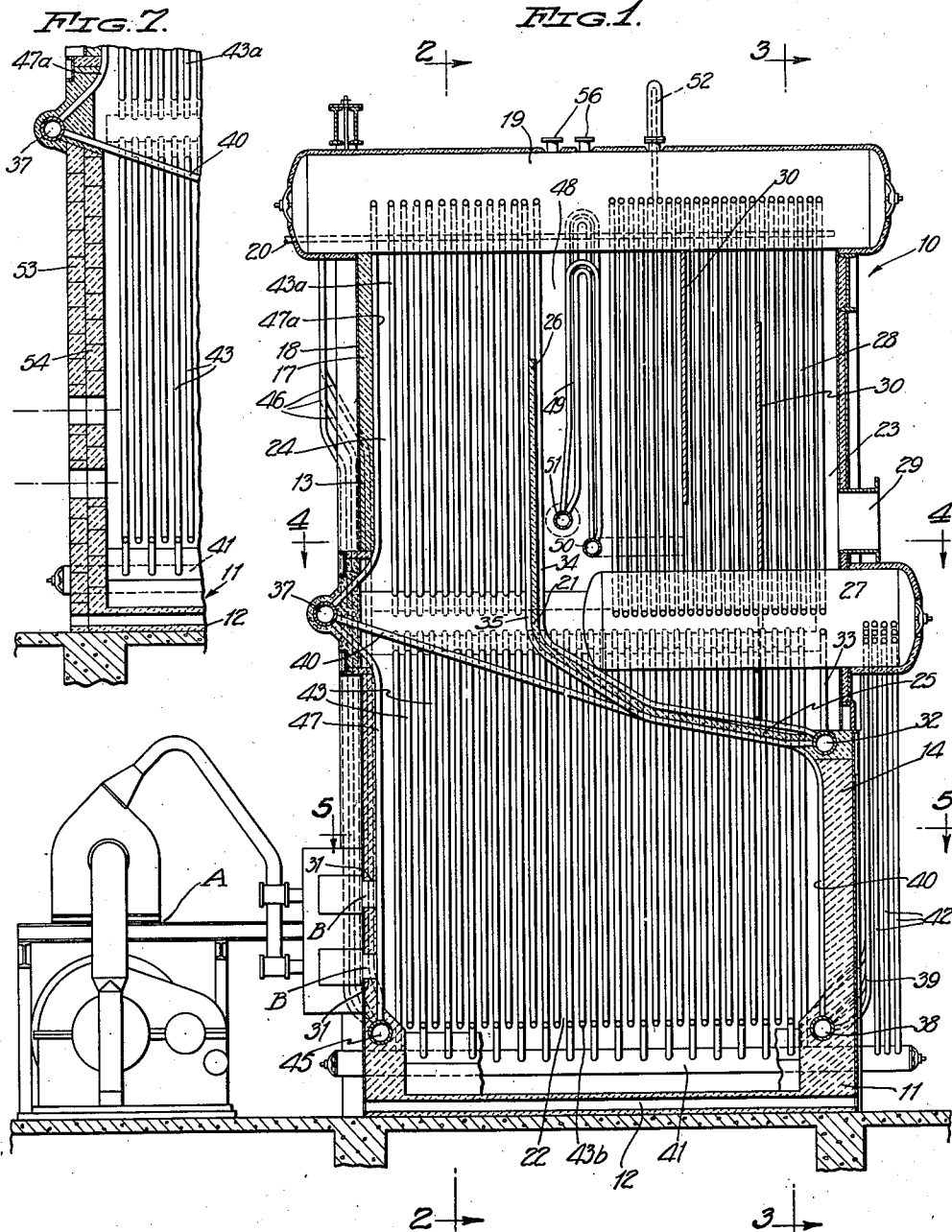
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2,306,097

STEAM GENERATOR

Filed Jan. 14, 1942

6 Sheets-Sheet 1



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WITNESS:
Ely & Pattison
1942

Dec. 22, 1942.

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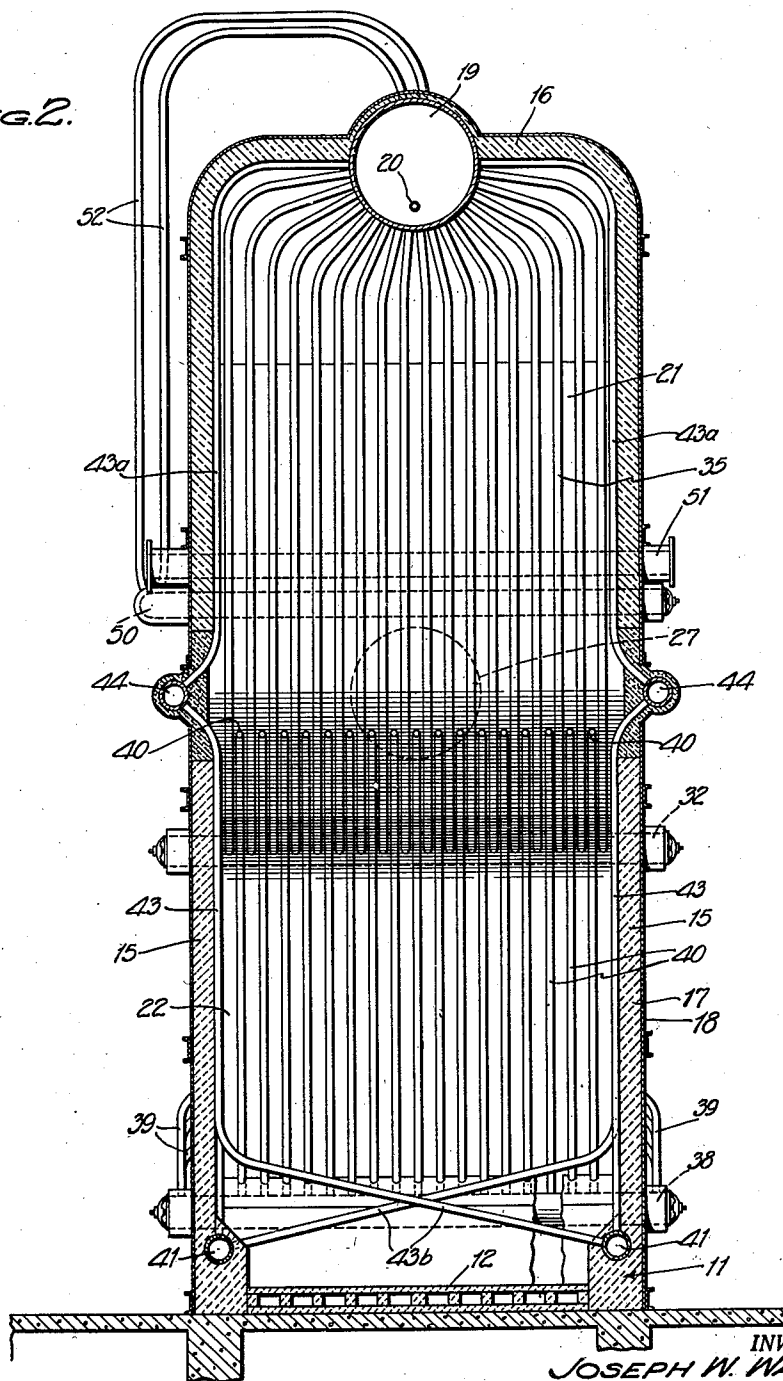
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STEAM GENERATOR

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6 Sheets-Sheet 2

FIG. 2.



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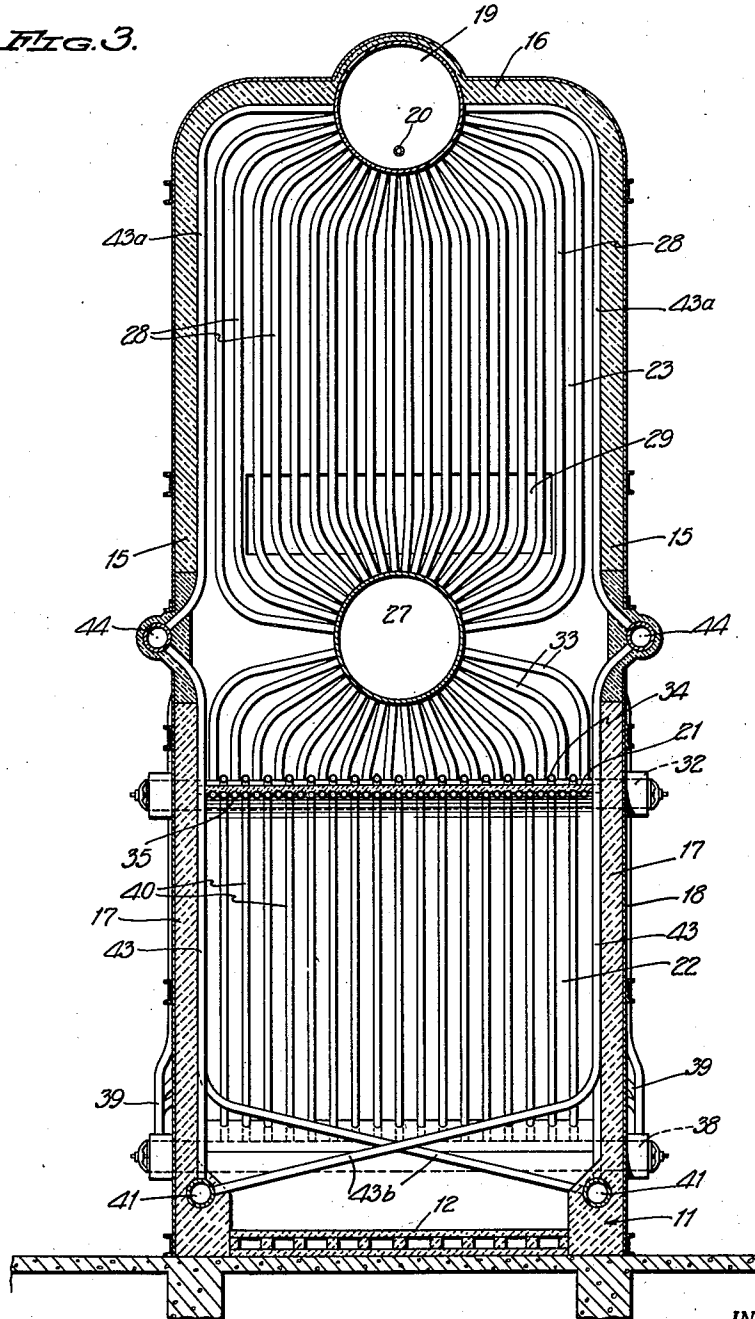
2,306,097

STEAM GENERATOR

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6 Sheets-Sheet 3

FIG. 3.



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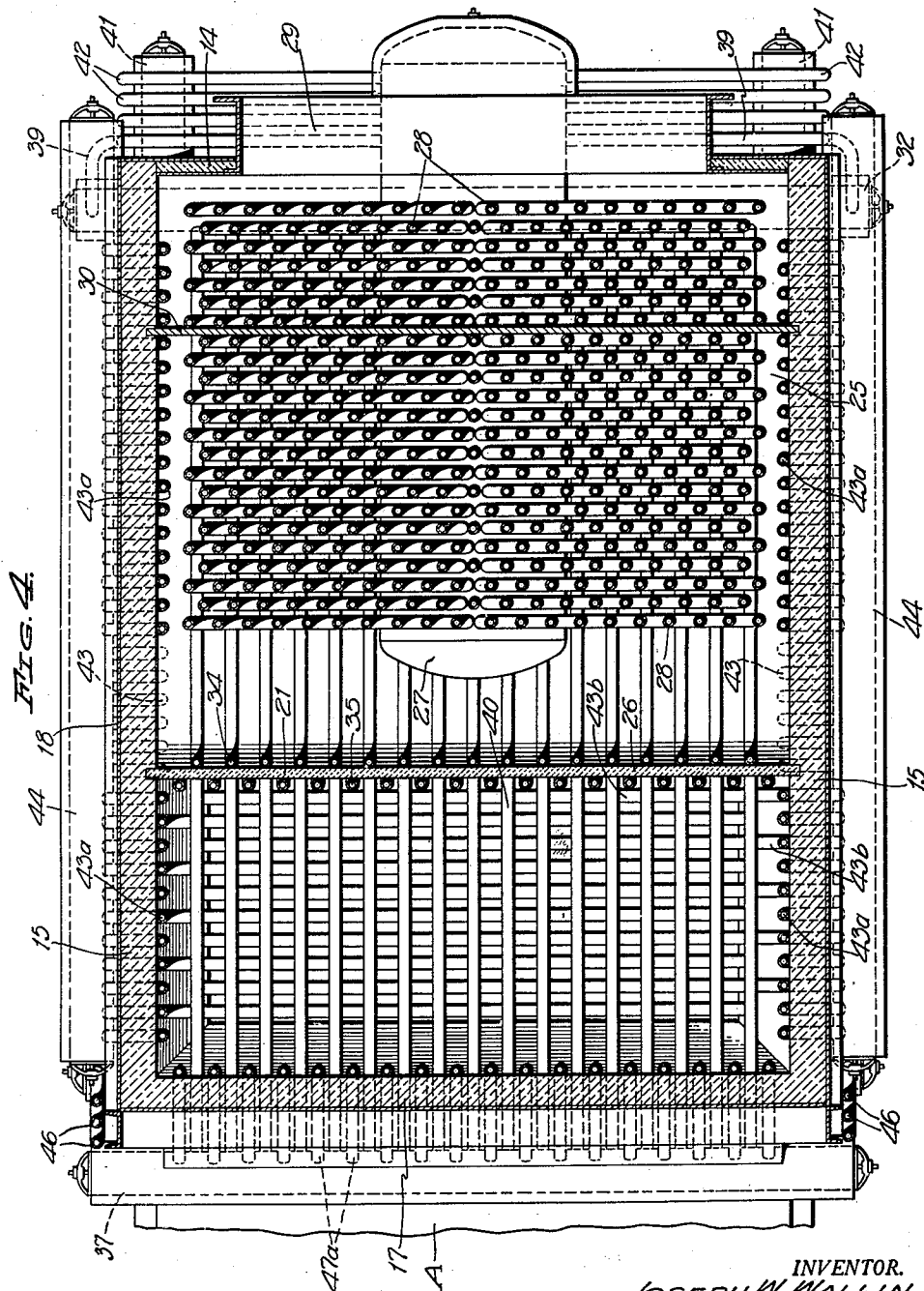
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2,306,097

STEAM GENERATOR

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6 Sheets-Sheet 4



WITNESS

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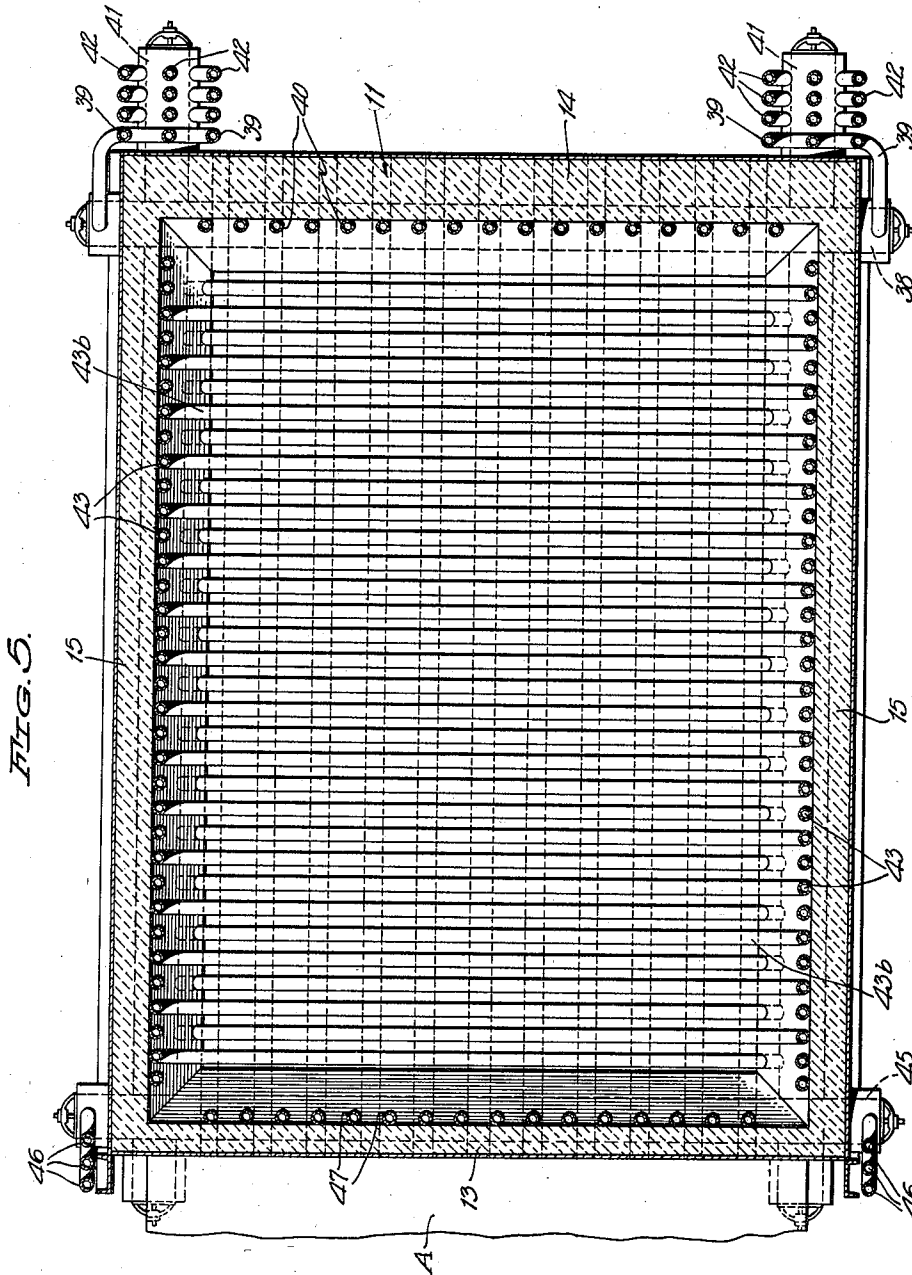
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2,306,097

STEAM GENERATOR

Filed Jan. 14, 1942

6 Sheets-Sheet 5



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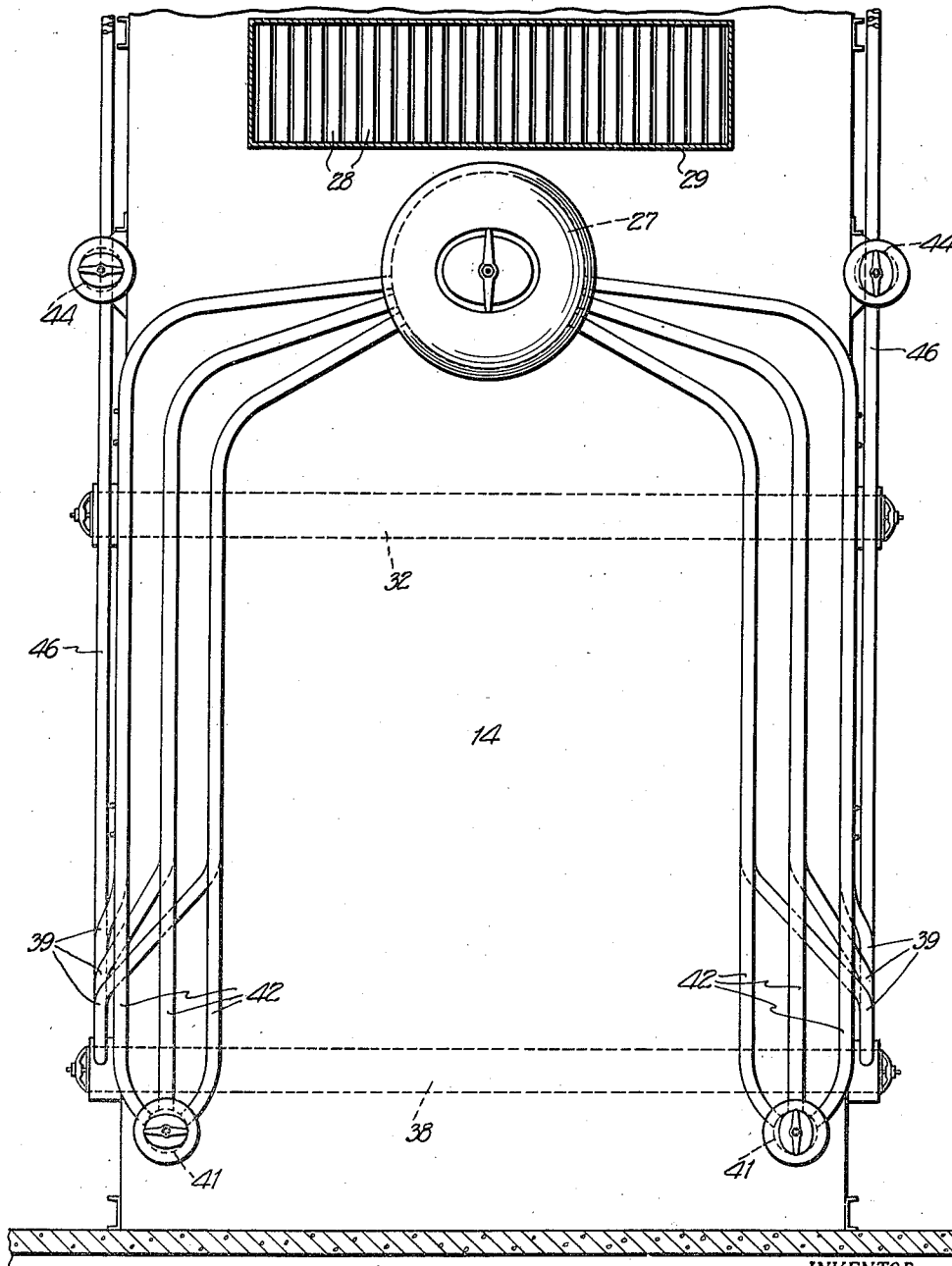
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STEAM GENERATOR

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6 Sheets-Sheet 6

FIG. 6.



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UNITED STATES PATENT OFFICE

2,306,097

STEAM GENERATOR

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10 Claims. (Cl. 122—347)

This invention relates to improvements in steam generators of the type set forth in U. S. Letters Patent No. 2,097,268 granted to Simon C. Best on October 26, 1937.

One of the important features of this invention resides in a steam generator embodying the broad principles set forth in the above mentioned patent, but which is primarily designed for the burning of fuel in suspension.

Other features of the invention are to provide a steam generator in which the parts of the same are arranged to produce a compact unit requiring a minimum amount of installation space, and capable of being economically operated at very high rates of combustion and steam generation without frequent and costly repairs.

Another feature of the invention is the provision of a steam generator which consists of a pressure unit or boiler, superimposed over a furnace or combustion chamber, the whole of which is enclosed in a setting of either all refractory material, or a combination of refractory material, insulating material and an outer steel jacket or casing, the refractory materials being partially protected from the heat generated in the furnace or combustion chamber by water tubes which constitutes an adjunct of the pressure unit.

A further feature of the invention is to provide a novel slag screen consisting of water tubes at the outlet of the furnace or combustion chamber to effect a cooling of molten fuel or ash to prevent it from leaving the furnace in a sticky state and which otherwise would have a tendency to foul the heat absorbing surfaces of the steam generating and superheating tubes of the steam generator unit which are exposed to the waste gases of combustion.

A further feature of the invention is to provide a steam generator with water walls consisting of spaced upright water tubes arranged on one or more side walls, floor, and the roof of the combustion chamber in a novel manner so that high rates of fuel combustion can be maintained without damage to the refractory material which surrounds the furnace outside of and adjacent to the water wall tubes.

A still further feature of the invention is to provide in a steam generator of the aforesaid type, a steam superheater over which gases from the furnace will flow as they travel toward the gas outlet.

Other novel features of the invention will become apparent as the specification is read in conjunction with the accompanying drawings, in which:

Figure 1 is a vertical longitudinal sectional view through the steam generator.

Figure 2 is an enlarged vertical transverse sectional view taken substantially on the line 2—2 of Fig. 1.

Figure 3 is an enlarged vertical transverse sectional view taken substantially on the line 3—3 of Fig. 1.

Figure 4 is an enlarged horizontal sectional view on the line 4—4 of Fig. 1.

Figure 5 is an enlarged horizontal sectional view on the line 5—5 of Fig. 1.

Figure 6 is a fragmentary rear elevational view of the steam generator with parts in section.

Figure 7 is a fragmentary vertical sectional view of an alternative front wall construction.

Referring to the drawings by reference characters, the numeral 10 designates the steam generator in its entirety which includes a setting 11 having a floor 12, a front wall 13, a rear wall 14, opposed side walls 15—15, and a roof or top wall 16. The walls of the setting 11 are constructed of refractory material 17 enclosed in an outer steel jacket or casing 18. Supported by the front and rear walls 13 and 14 of the setting and disposed under the roof 16 is a longitudinal steam and water drum 19. The drum 19 is located midway between the opposed side walls 15—15 and has its ends extending beyond the front and rear walls for reasons hereinafter explained. A water feed pipe 20 enters the drum 19 from the front end thereof to facilitate the feeding of water to the drum as and when necessary.

The interior of the setting 11 is divided by a substantially L-shaped refractory partition wall 21 into a lower furnace or combustion chamber 22, and a superposed upper heating chamber of gas flow compartment 23 which are connected by a forwardly disposed gas passageway 24. The L-shaped partition wall 21 extends transversely of the setting and includes an upwardly inclined wall portion 25 having its rear end connected to the rear wall 14 and which forms a roof for the combustion chamber 22 and a vertical wall portion 26 disposed parallel to the front wall 13 in spaced relation thereto to form the passageway 24. The top of the wall portion 26 terminates short of the roof 16 to provide a bridge wall over which the waste gases sweep as they pass from the passageway 24 to the gas flow compartment 23.

Mounted within the setting 11 and disposed adjacent the bottom of the compartment 23 is a longitudinal water drum 27 having its rear end extending beyond the rear wall 14. The water drum 27 is disposed in vertical alinement with the water and steam drum 19 and is connected to the drum 19 by rows of spaced vertical water tubes 28 having their ends entering the drums radially of the longitudinal axis thereof. The tubes 28 of one transverse row of tubes are staggered relative to the next adjacent row to cause the heated gases to completely surround the tubes as the gases pass through the compart-

ment 23 to the gas outlet 29 provided in the rear wall 14 just above the water drum 27. The flow of waste gases through the compartment 23 is caused to take an undulated path by reason of the spaced vertical overlapping baffles 30 which extend transversely of the compartment intermediate certain of the rows of tubes 28. The two baffles 30 shown in the drawings provide the compartment 23 with a three pass boiler, however, the unit may be provided with a greater number of baffles depending upon the capacity of the generator unit. The waste heated gases flow over the top of the bridge wall portion 26 into the compartment 23, then down beneath the front baffle 30, upwardly between the two baffles 30—30, over the rear baffle, thence downwardly and out through the gas outlet 29. Thus water flowing downwardly from the steam and water drum is initially heated as it flows through the tubes 28 to the lower drum 27.

The combustion chamber 22 burns fuel in suspension, and whereas oil may be burned therein, a stoker A has been shown in Figure 1 having powdered fuel injection jets B—B entering the chamber through openings 31 in the front wall 13.

Mounted in the rear wall 14 of the setting at its juncture with the partition wall 21 is an upper transverse rear header 32 which is fed with water from the rear of the water drum 27 by short vertical tubes 33. The header 32 is directly connected to the steam and water drum 19 by a spaced row of transversely disposed water tubes 34 which are substantially parallel to and disposed adjacent the rear or inner side of the partition wall 21 and said tubes act to cool refractory material forming the roof 25 of the combustion chamber and rear wall 26 of the passageway 24. Similar spaced water tubes 35 also lead from the header 32 direct to the upper drum 19 and are disposed on the front side of the partition wall 21 in parallel relation thereto and are disposed thereagainst. The tubes 35 are staggered relative to the tubes 34 and the said tubes 34 and 35 cooperate to effect a cooling of the refractory partition during operation of the generator unit.

A lower transverse rear wall header 38 is disposed adjacent the bottom of the combustion chamber 22 within the refractory rear wall 14, and water is fed from the water drum 27 to opposite ends of the header 38 by two sets of vertical water tubes 39—39 there being three tubes to each set although more or less may be employed depending upon the capacity of the generator unit. The tubes 39 are disposed exteriorly of the rear wall 14 and have their upper ends connected to the rearwardly extending end of the drum 27 the plane of the horizontal axis thereof, whereas the lower ends of said tubes are bent forwardly, laterally outwardly, and downwardly and enter the top of the header 38 radially thereof as best illustrated in Figures 1 and 6. A transverse row of water tubes 40 rise upwardly from the header 38 against the inner side of the rear wall of the combustion chamber and extend forwardly and upwardly against the refractory roof 25 of the combustion chamber and across the entrance to the passageway 24 to the front wall 13 where they enter a junction header 37 located exteriorly of the front wall and transversely thereof. The portions of the spaced tubes 40 which bridge the passageway 24 form a slag screen to cool particles of molten fuel or ash and prevent it from leaving the combustion chamber 22 in a sticky state, which otherwise would have a tendency to foul the heat absorbing surfaces of

the water tubes 23 and other steam generating and superheating parts to be hereinafter described.

Extending longitudinally of the setting 11 within the side walls 15—15 adjacent the bottom of the combustion chamber 22 are longitudinal side wall headers 41—41, the ends of which extend exteriorly beyond the front wall 13 and rear wall 14. Water is fed to the headers 41—41 from the rearwardly projecting end of the water drum 27 by two groups of vertical downcomer tubes 42—42, there being three tubes to each group, although more or less tubes may be provided depending upon the capacity of the generator unit. The upper portions of the tubes 42 are in alignment with the tubes 39 as best illustrated in Figure 6 of the drawings. Rising from the side wall headers 41—41 is a bank of lower side wall up-comer tubes 43, the same extending the height of the combustion chamber 22 and being disposed against the inner sides of the side walls 15—15 of the setting. Whereas the tubes 43 may rise vertically against the respective side walls 15—15 from their respective headers 41—41, I have illustrated the lower ends of alternate tubes on one side as crossing over the bottom of the combustion chamber to the header on the opposite side wall. The cross over tube from one side of the combustion chamber is in line with the tube coming straight down to that particular side wall header. The cross over portions 43b of the side wall tubes is subjected to the intense heat of the combustion chamber. The upper ends of the tubes 43 pass through the side walls and connect with junction headers 44—44 disposed longitudinally and exteriorly of the side walls. An upper bank of tubes 43a—43a have their lower ends connected to the junction headers 44—44 and rise upwardly within the setting against the side walls 15—15 thereof with their upper ends entering the steam and water drum on a plane substantially in horizontal alignment with the axis of the drum. The upper ends of the tubes 43a conform to and are disposed against the refractory top wall 16 of the setting as illustrated in Figures 2 and 3. Water from the side wall headers 41—41 rise upwardly through the tubes 43 and 42a to water cool the refractory side walls 15—15 and top wall 16, said water being heated by the gases of combustion in the combustion chamber 22 and by the heated waste gases of combustion as they travel up the passageway 24 and through the compartment 23 in an undulated path. The water rising in the tubes 43 and 43a is transformed into steam which enters the steam and water drum 19. Any water not transformed into steam also rises and returns to the steam and water drum 19, from whence it is recirculated through the system.

The water cooling of the front wall 13 is optional, for such cooling is shown in Figures 1 to 6, but is omitted in the modified form illustrated in Figure 7. In Figures 1 to 6, a front wall header 45 is embedded in the refractory front wall 13 adjacent the bottom of the combustion chamber 22. The header 45 extends horizontally and transversely of the front wall and has its ends extending exteriorly beyond the side walls 15—15 as shown in Figure 5. Water is fed to the extending ends of the header 45 by two sets of downcomer water tubes 46, there being three tubes 46 to each set. The tubes 46 are disposed exteriorly of the front wall and connect with the bottom of the steam and water drum 19 at the front end thereof. A lower transverse row of water wall tubes 47 connect the front wall header 45 with

the junction header 37, said tubes 47 being disposed against the inner side of the front wall 13. The tubes 47 are exposed to the heat of the combustion chamber and steam and water therein rises upwardly to the junction header 37. Steam and water from the junction header 37 is carried to the steam and water drum by a transverse row of upper front wall tubes 47a, which tubes are disposed against the upper portion of the front wall to water cool the refractory material from which it is constructed.

A space 48 is provided between the vertical wall portion 26 and the front of the bank of tubes 23 within which a superheater 49 is mounted so as to be exposed to the intense heat of the hot waste gases of combustion as they sweep over the top of the wall 26 into the compartment 23. The superheater 49 is provided with a steam inlet header 50 located adjacent the front end of the drum 27 and which extends transversely of the setting 11. The superheater tubes of the superheater 49 have their inlet ends connected to the inlet header 50 and their outlet ends connected to a transverse steam outlet header 51. The inlet header is connected to the top of the steam and water drum by steam tubes 52, whereas the outlet header 51 may be connected to a take off pipe or tubes (not shown).

In operation, fuel in suspension is burned within the combustion chamber 22 and the hot waste gases of combustion rise upwardly through the passageway 24, over the wall portion 26, past the superheater 49 and through the compartment 23 in an undulated path to the gas outlet 29. Water is circulated from the steam and water drum 19 to the water drum 27 through downcomer tubes 28, from the lower drum to upper rear header 32 through tubes 33, and to lower rear wall header 38 through tubes 39. The water reaching the headers 32 and 38 is heated by reason of its passage through the tubes 28 which are subjected to the heat of the waste gases of combustion, and water from the header 32 rises upward through the tubes 34 and 35 and is further heated. Water from the lower header 39 rises in the tubes 40 and flows forwardly in the slag screen portions thereof to the junction header 37, from where water and steam is carried to the drum 19 by the tubes 47a. Certain of the water in the tubes 34, 35, and 40 is transformed into steam which rises and flows with any hot water into the longitudinal steam and water drum 19. Due to the close proximity of the tubes 34, and 35 with the partition wall 21 and tube 40 with the rear wall 14, said walls are cooled and prevented from overheating, which latter condition would result in the shortening of the life of the setting 11. Water is fed from the drum 27 to the side wall headers 41 by the downcomer tubes 42, from where it rises in the tubes 43 to the junction headers 44—44, tubes 43a to the longitudinal steam and water drum 19. Certain of the water rising in the tubes 43, 43a is transformed into steam, which steam enters the drum 19 with the return water. The tubes 43, 43a, act to cool the refractory side walls 15—15 and top wall 16. The front wall 13 is water cooled by the upcomer tubes 47 and 47a which receive their water from the front header 45, which is fed by water direct from the steam and water drum 19 by means of the connecting downcomer tubes 46. Accumulated steam within the drum 19 may be taken off through steam outlets 56 in the top thereof.

From the foregoing description it will be un-

derstood that the tubes 40, 43, 43a, 47, 47a, 34 and 35 are subjected to radiant heat from fuel burned in suspension within the combustion chamber 22, and which will effect a rapid generation of steam at a comparatively high rate. Thus, the steam generating capacity of the steam generator unit 10 will be very high in proportion to the area of the floor space occupied. The water drum 27 is amply protected from the radiant heat of the combustion chamber by reason of the water cooled refractory partition wall 21. The heated waste gases of combustion are compelled to flow past the slag screen forming tubes 40 before entering the passageway 24, and while traveling upwardly in the passageway 24, through the superheater 49 and through a circuitous path in the compartment 23 containing the bank of tubes 28, the gases being cooled by the transfer of heat to the surfaces of said tubes traversed by the gases prior to the escape of the gases through the gas outlet 29.

In Figure 7 there is illustrated a modified construction of the lower front wall of the setting 11. In this modified structure the water cooling of the front wall of the combustion chamber 22 is eliminated and in lieu thereof, the lower front wall is constructed of red brick 53 backed up on the inside of fire brick 54. The two thicknesses of brick provide a wall structure capable of withstanding the heat of the combustion chamber at the front thereof. Aside from the elimination of the front wall header 45, upcomer tubes 47 and downcomer tubes 46, the steam generator fragmentarily shown in Figure 7 is the same as that shown in Figures 1 to 6 inclusive and further explanation is not believed necessary.

While I have shown and described what I consider the preferred embodiments of my invention, I wish it to be understood that such changes in construction and design as come within the scope of the appended claims may be resorted to if desired, without departing from the spirit of the invention.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a steam generator for the burning of fuel in suspension, a setting having a front wall, a rear wall, opposed side walls and a top wall; a transverse partition wall extending forwardly and upwardly from said rear wall and terminating in spaced relation to the top and front walls and dividing the interior of said setting into a lower combustion chamber and an upper heating compartment, a smoke outlet provided at the rear of the heating compartment, a longitudinal steam and water drum at the top of said setting extending the length thereof, a longitudinal water drum disposed within the heating compartment adjacent the bottom thereof, a bank of downcomer water tubes connecting the water drum with the steam and water drum, a transverse header adjacent the bottom of said rear wall, downcomer water tubes connecting said transverse header with said water drum, water tubes extending upwardly from the transverse header along the rear wall and forwardly across the combustion chamber to provide a slag screen therefor, and means connecting the last named water tubes to the steam and water drum.

2. In a steam generator for the burning of fuel in suspension, a setting having a front wall, a rear wall, opposed side walls and a top wall; a transverse partition wall extending forwardly and upwardly from said rear wall and termi-

nating in spaced relation to the top and front walls and dividing the interior of said setting into a lower combustion chamber and an upper heating compartment, a smoke outlet provided at the rear of the heating compartment, a longitudinal steam and water drum at the top of said setting extending the length thereof, a longitudinal water drum disposed within the heating compartment adjacent the bottom thereof, a bank of downcomer water tubes connecting the water drum with the steam and water drum, a transverse header adjacent the bottom of said rear wall, downcomer water tubes connecting said transverse header with said water drum, water tubes extending upwardly from the transverse header along the rear wall and forwardly across the combustion chamber to provide a slag screen therefor, and means connecting the last named water tubes to the steam and water drum, longitudinal side wall headers adjacent the bottom of the combustion chamber, downcomer water tubes connecting the rear of the water drum to the rear of the side wall headers, and side wall water tubes connecting the side wall headers to said upper drum.

3. In a steam generator as set forth in claim 2, including a front transverse header disposed adjacent the bottom of the combustion chamber, and vertical tubes connecting the front wall header to said upper drum.

4. In a steam generator as set forth in claim 2, including a second transverse header disposed above the first transverse header adjacent the rear wall, water tubes connecting the second transverse header to said water drum, and water tubes connecting the second transverse header with said steam and water drum, certain of said last named water tubes being disposed adjacent one side of the partition wall and the others being disposed adjacent the other side thereof and being substantially parallel thereto.

5. In a steam generator as set forth in claim 2, in which alternate side wall water tubes at each side of the setting extend transversely and downwardly across the bottom of the combustion chamber and connect with the side wall header at the opposite side thereof to provide crossed tube portions adjacent the bottom of the combustion chamber.

6. In a steam generator for burning fuel in suspension, a setting having a front wall, a rear wall, opposed side walls, and a top wall; a substantially L-shaped refractory partition wall within said setting extending forwardly from the rear wall thereof and disposed in spaced relation to the front and top walls and dividing the interior of the setting into a lower combustion chamber, an upper heating compartment and a communicating gas passage, a smoke and gas outlet provided at the rear of said heating compartment, an upper longitudinal steam and water drum at the top of said setting, a lower longitudinal water drum disposed adjacent the bottom of said heating compartment, a bank of downcomer water tubes connecting the upper water and steam drum with the lower water drum, side wall headers disposed adjacent the bottom of said combustion chamber and extending beyond the rear wall, water tubes connecting the rear of the lower drum with the rear end of the side wall headers, side wall water tubes connecting the side wall headers with said upper steam and water drum, the upper end portions of the side wall water tubes being disposed adjacent the top wall.

7. In a steam generator as set forth in claim 6 including, a rear transverse header adjacent the top of the combustion chamber, water tubes connecting the rear transverse header to the lower water drum, tubes extending forwardly from said rear transverse header across the top of the combustion chamber to the front wall to provide a slag screen between the combustion chamber and the outlet passage, a front transverse header with which the slag screen tubes connect, and tubes connecting the front transverse header with the front end of the upper steam and water drum.

8. In a steam generator as set forth in claim 6, including a lower rear transverse header adjacent the bottom of the combustion chamber, downcomer water tubes connecting the rear transverse header to the lower water drum, upcomer tubes connecting the lower rear transverse header to the upper steam and water drum and disposed along the rear wall and the front sides of the partition wall, an upper rear transverse header disposed adjacent the top of the combustion chamber, water tubes connecting the upper rear transverse header to the lower water drum, and upcomer tubes connecting the upper rear transverse header with the upper steam and water drum, alternate tubes of said last named upcomer tubes being disposed adjacent and substantially parallel to the respective sides of the partition wall.

9. In a steam generator, a setting having a front wall, a rear wall, opposed side walls, and a top wall, a longitudinal steam and water drum at the top of said setting and extending the length thereof, a refractory transverse partition wall having a vertical portion terminating short of the top wall, a downwardly and rearwardly inclined portion connected to the vertical portion and extending to the rear wall, said partition wall dividing the interior of the setting into a lower combustion chamber, an upper heating compartment, and a vertical communicating passage between said combustion chamber and said heating compartment, a water drum disposed at the bottom of said heating compartment and having its rear end extending outwardly from said rear wall, side wall headers disposed adjacent the bottom of said combustion chamber and having their rear ends extending beyond the rear wall, downcomer water tubes connecting the rearwardly extending ends of the water drum and side wall headers, side wall water cooling upcomer tubes connecting the side wall headers with the upper drum and being disposed adjacent and parallel to the side and top walls, a transverse header at the bottom of the rear wall, water tubes connecting the transverse header to the water drum, tubes extending from the transverse header to the front wall and bridging the entrance to the vertical passage and forming a slag screen for the waste gases of combustion as they leave the combustion chamber, and vertical tubes connecting the front ends of the slag screen tubes with the steam and water drum.

10. In a steam generator as set forth in claim 9, including a second transverse header superposed relative to the first transverse header, tubes directly connecting the second transverse header with the steam and water drum, said last tubes being alternately disposed adjacent and substantially parallel to the opposed sides of the partition wall, to effect a water cooling thereof.