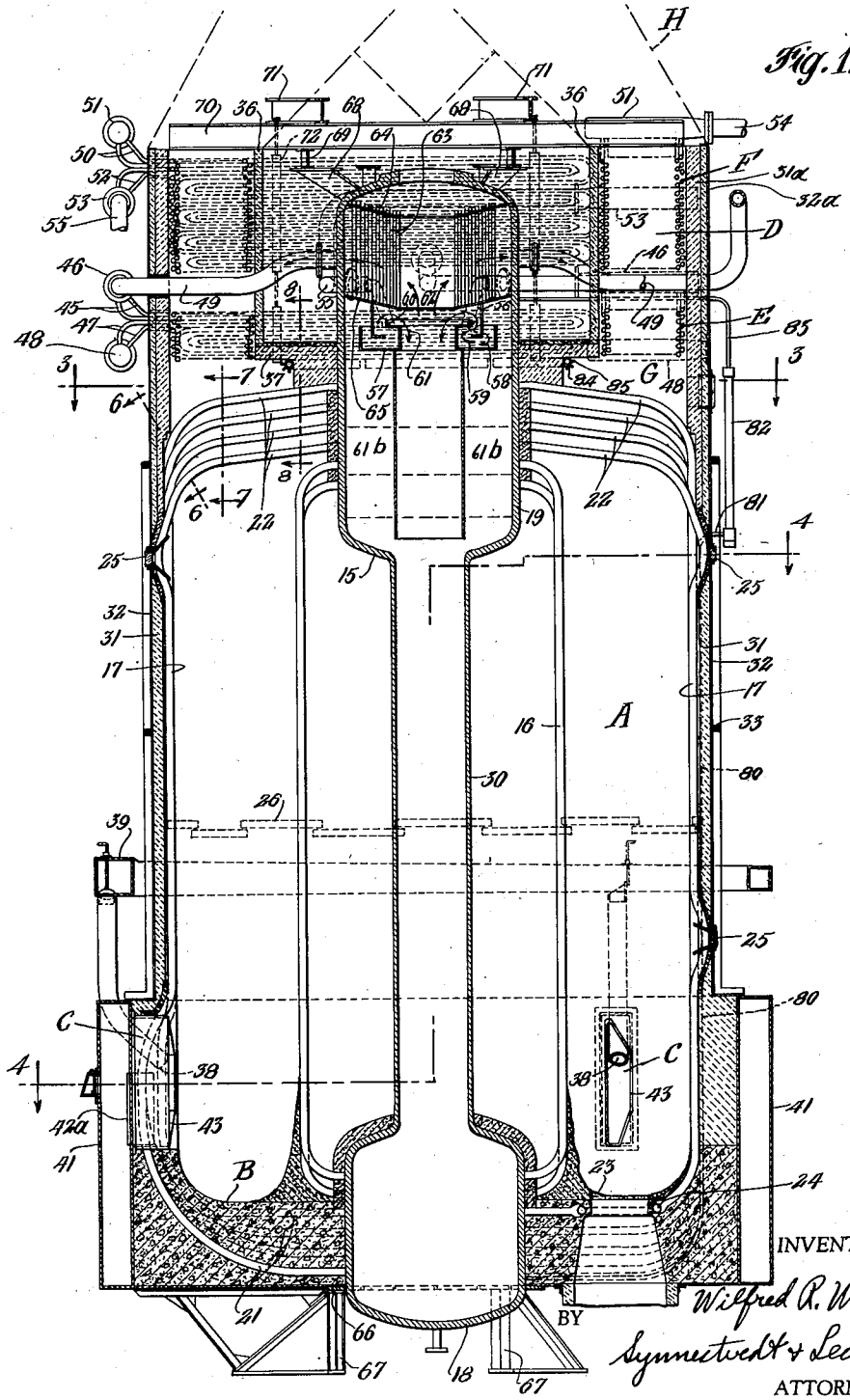
Feb. 3, 1942. W. R. WOOD 2,271,880

STEAM GENERATOR

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Fig. 1.



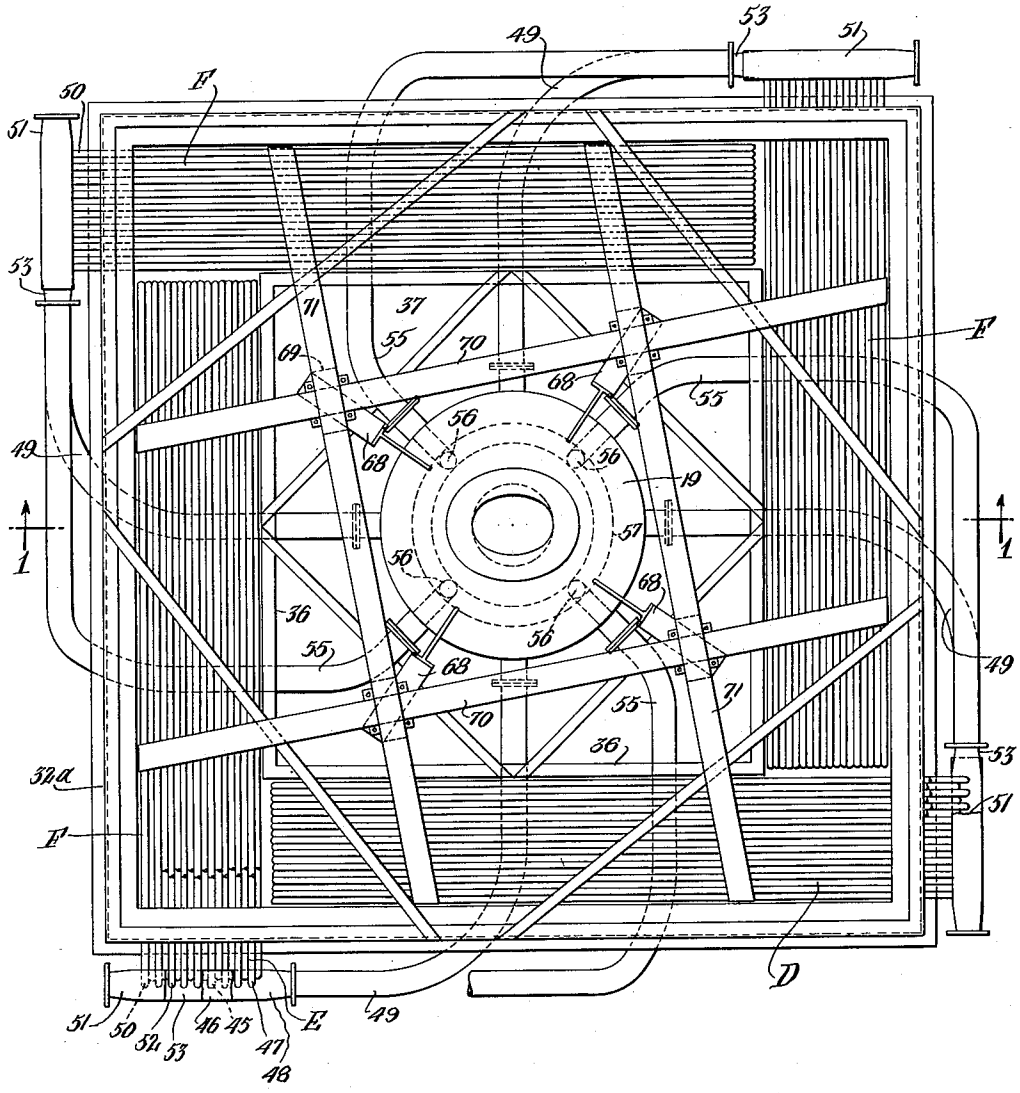
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STEAM GENERATOR

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Fig 2.



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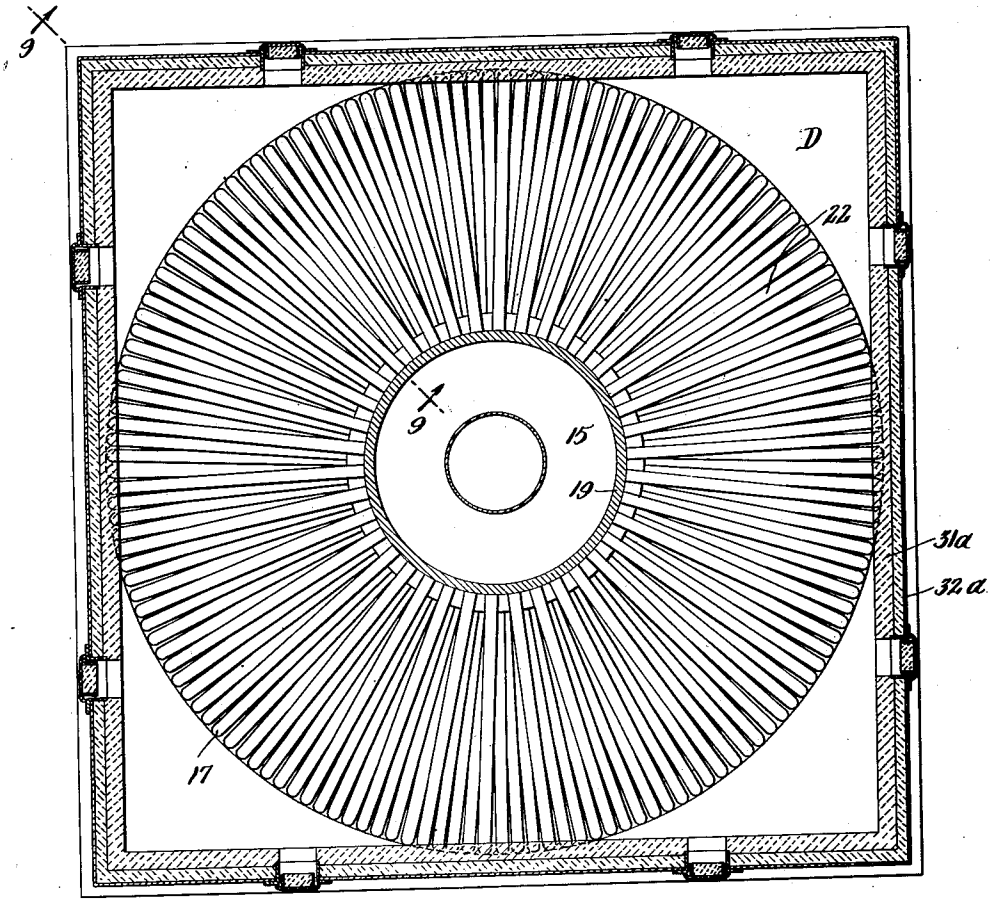
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STEAM GENERATOR

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Fig. 3.



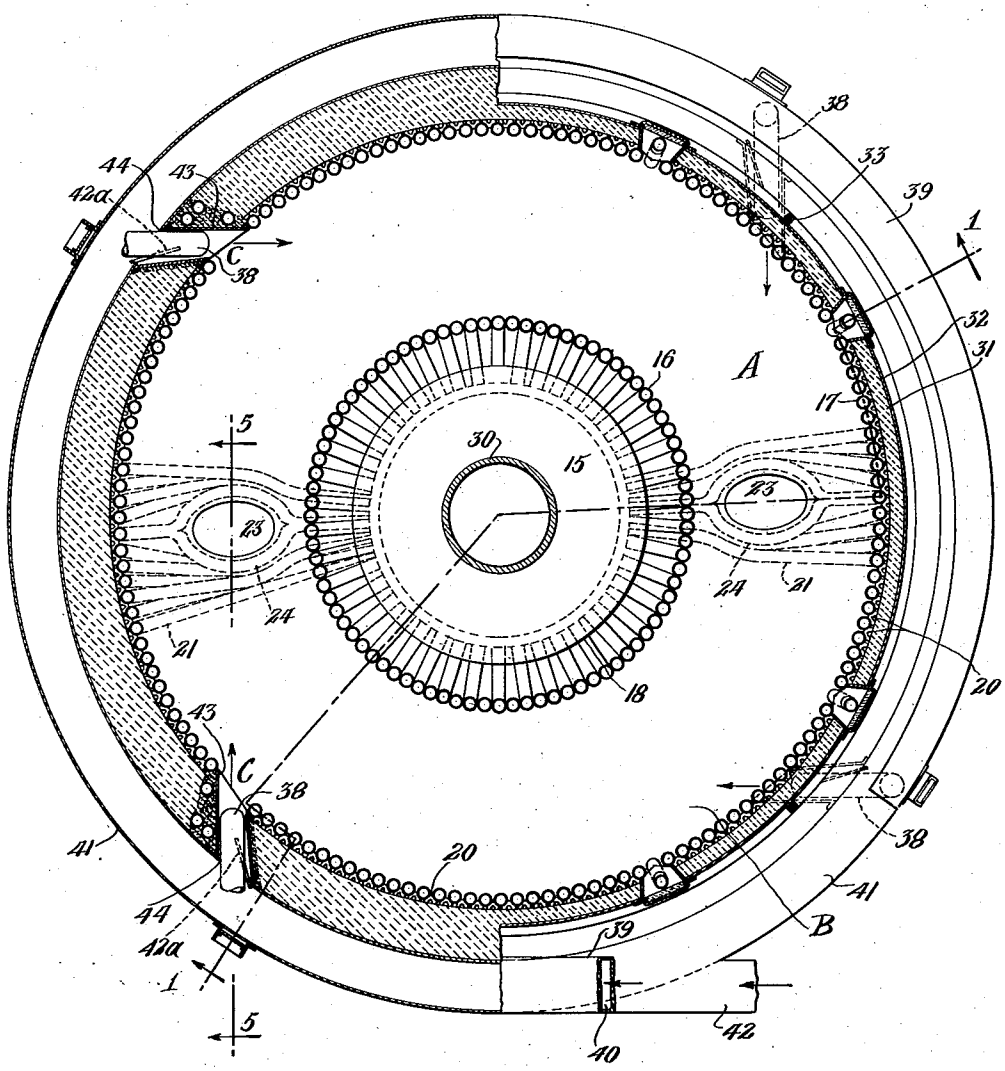
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STEAM GENERATOR

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Fig. 4.



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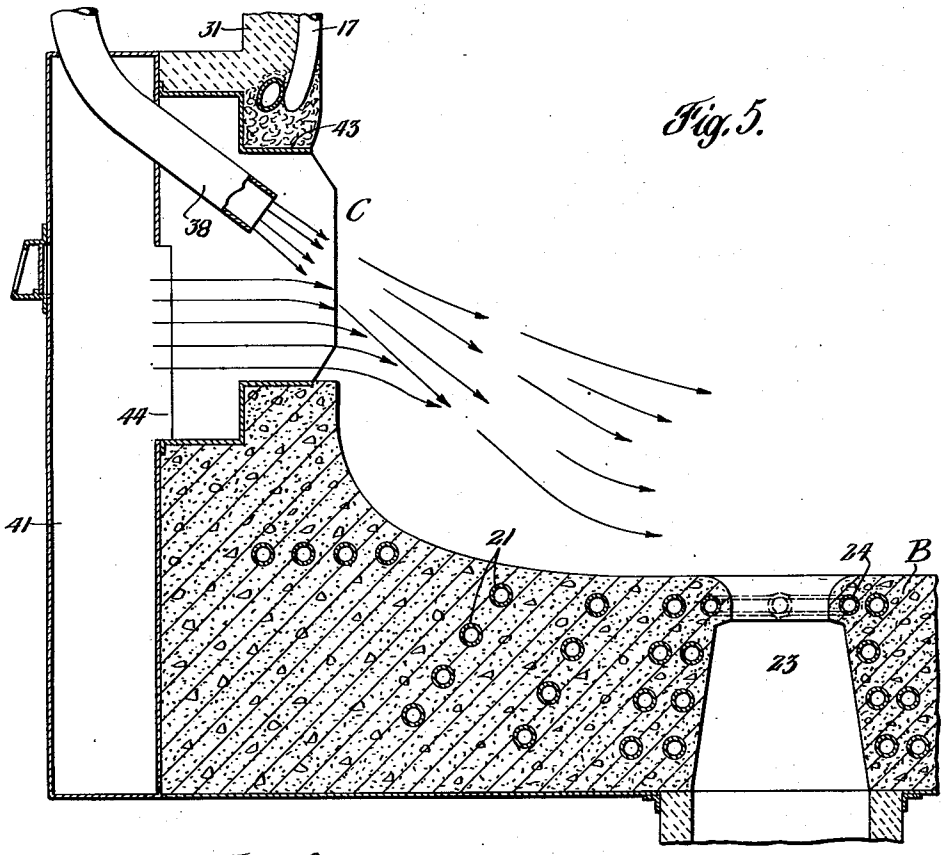


Fig. 5.

Fig. 6.

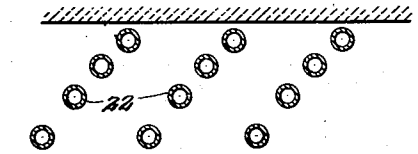
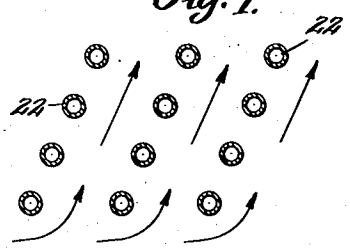


Fig. 7.



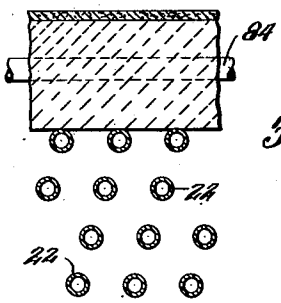


Fig. 8.

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STEAM GENERATOR

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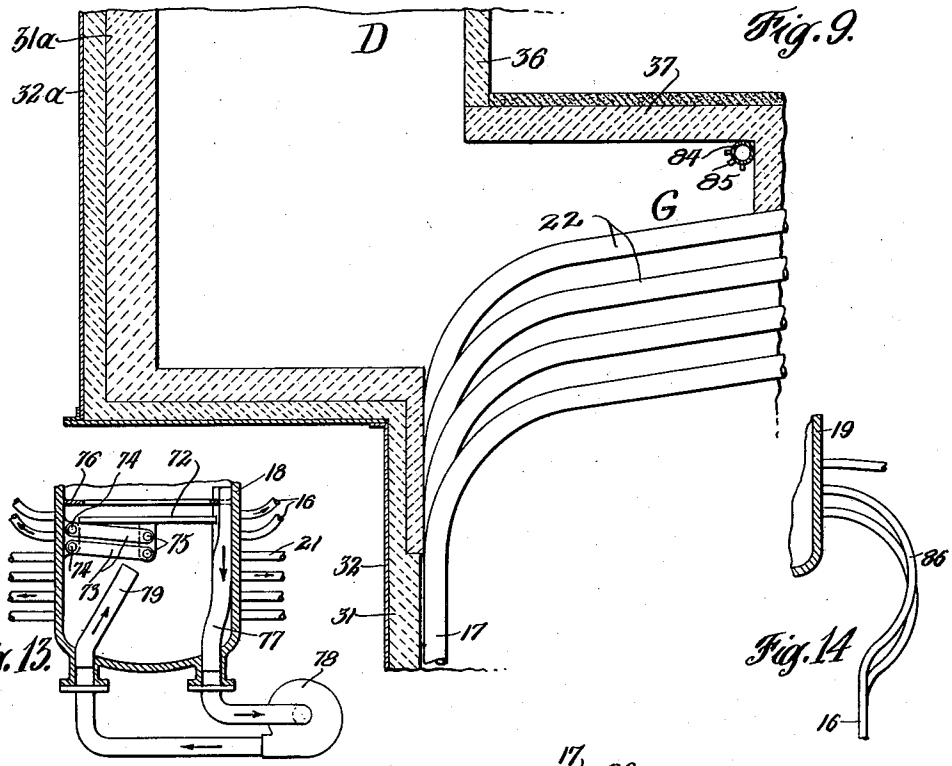


Fig. 9.

Fig. 13.

Fig. 14.

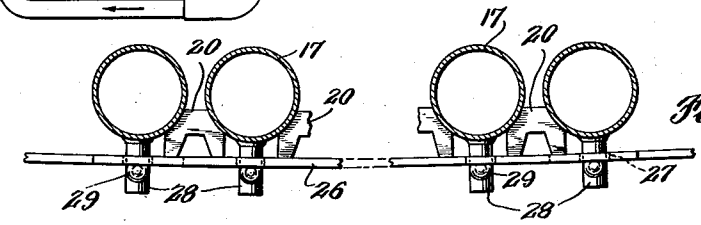


Fig. 11.

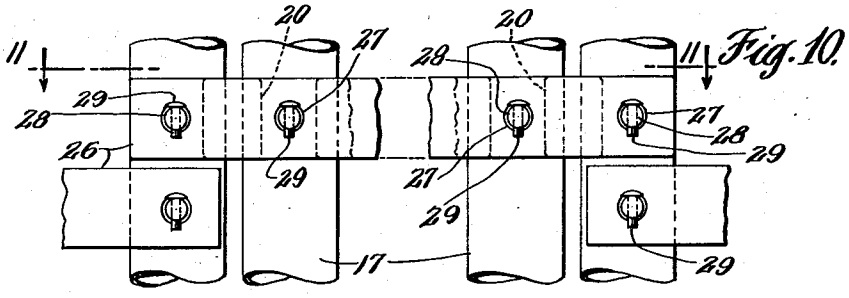


Fig. 10.

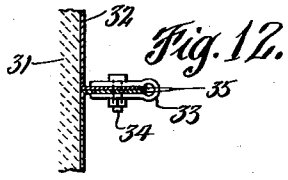


Fig. 12.

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Patented Feb. 3, 1942 2,271,880

UNITED STATES PATENT OFFICE

2,271,880

STEAM GENERATOR

Wilfred Rothery Wood, New York, N. Y., assignor to Combustion Engineering Company, Inc., New York, N. Y., a corporation of Delaware

Application September 10, 1938, Serial No. 229,368

10 Claims. (Cl. 122—235)

My invention relates to steam generators and has for its primary object the simplification and improvement of steam generators of the type disclosed in my prior Patent No. 2,044,270.

Improved features, among others appearing hereinafter, reside in the construction and arrangement of the drum, the boiler tubes, the superheater and economizer, the steam separating and drying mechanism, the gas passages, the structural supporting parts, and of the parts generally to simplify and eliminate certain erection problems, and to enable me to provide a steam generator of small size but of high capacity and marked operating flexibility.

How the foregoing, together with such other objects and advantages as may hereinafter appear, or are incident to my invention, are realized, is illustrated in preferred form in the accompanying drawings, wherein—

Figure 1 is a sectional elevation through a steam generator constructed in accordance with my invention, the lower portion of the section being taken substantially on the line 1—1 of Figure 4 and the upper portion on the line 1—1 of Figure 2;

Figure 2 is an enlarged plan view of the steam generator;

Figure 3 is a plan section taken substantially on the line 3—3 of Figure 1;

Figure 4 is a plan section taken substantially on the line 4—4 of Figure 1;

Figure 5 is an enlarged fragmentary vertical section taken substantially on the line 5—5 of Figure 4;

Figures 6, 7 and 8 are enlarged fragmentary sectional views taken substantially on the lines 6—6, 7—7, and 8—8 respectively, of Figure 1;

Figure 9 is an enlarged fragmentary vertical section taken substantially on the line 9—9 of Figure 3;

Figure 10 is an enlarged fragmentary elevation showing a detail of the wall tube arrangement;

Figure 11 is a plan section taken on the line 11—11 of Figure 10;

Figure 12 is an enlarged fragmentary section illustrating a detail of the casing structure;

Figure 13 is a modification illustrating an arrangement for obtaining forced circulation in the boiler; and

Figure 14 is a modified arrangement of the inner wall tubes.

My improved steam generator comprises in general an upright centrally located drum 15, an inner set or group of circularly arranged upright boiler tubes 16, an outer set or group of circularly arranged upright boiler tubes 17, an upright annular combustion chamber A, a slagging bottom B for the combustion chamber, burner means C for introducing fuel and air into the combustion chamber, a space or chamber D above the combustion chamber, superheater means E and economizer means F located in the upper chamber D, an annular outlet G establishing connection between the combustion chamber A and the superheater and economizer chamber D, and an offtake H for the waste gases.

The tubes of the inner group 16 substantially abut so as to form a water-cooled metallic inner wall for the annular combustion chamber A. The tubes of this group are bent at their lower and upper ends for connection into the lower and upper portions 18 and 19, respectively, of the drum, it being noted that all of the tubes of the group are of the same length, but that the points of connection of alternate tubes into the drum are staggered with relation to the remaining tubes in order to give the proper ligament strength in the drum.

The tubes of the outer group 17 are spaced slightly apart as shown in Figure 4, and are backed by metallic blocks 20 in contact with the tubes.

The tubes of this group 17 have lower bent portions 21 for connection into the lower portion 18 of the drum, and upper bent portions 22 for connection into the upper portion 19 of the drum. By referring particularly to the tubes of the group 17 appearing at the left-hand portion of Figure 1, it will be seen that they are all of substantially the same length because successive tubes connect into successively higher points in both the lower and upper portions of the drum. In this instance I have shown the bent tube portions arranged in diagonal groups, so to speak, of four tubes each, this arrangement being employed all the way around the drums. The diagonal arrangement at the upper portion of the tubes is clearly illustrated in Figures 6, 7 and 8, and at the lower portion of Figure 5. Figure 7 also illustrates how this tube arrangement provides a slag screen at the top of the combustion chamber with the tubes sloped in the direction of rotation of the gases.

By referring to the right-hand portion of Figure 1, it will be seen that the section is taken through a slag discharge opening 23 provided in the bottom of the combustion chamber, and that a tubular ring 24 is employed at the periphery of the opening 23 for cooling purposes, this ring being connected into one of the outer boiler

tubes 17. I have shown two such slag discharge openings 23, and therefore two of the tubes 17 will include tubular rings 24, but the remaining tubes 17 of the outer wall, except for bent portions such as at the burners C and at the doors 25, will all be of substantially the same length as pointed out above.

The lower bent portions 21 of the tubes 17 are embedded in the bottom or floor of the furnace which is constructed of refractory material, such as broken brick.

In order to tie the tubes of the outer group together, I employ a metallic band or bands 26 preferably of sectional construction, as shown in Figures 1, 10 and 11, having circumferentially spaced holes 27 for receiving studs 28 which are welded to the tubes. The bands encircle the tubes and the blocks 20, and are secured in place by means of pins 29 which pass through the studs 28.

In this instance, I have shown the lower and upper portions 18 and 19 of the drum of larger diameter than the intermediate or connection portion 30. I prefer to make the drum of welded construction, and since all of the tubes of the inner and outer groups are connected into the enlarged portions of the drum, I make these portions heavier than the intermediate portion of the drum where no tubes are connected.

The tubes of the outer group 17 are backed by sheathing 31 of refractory material which is enclosed in a cylindrical metallic casing 32 of sectional construction. The sections of the casing are fastened together by means of clips 33 (see Figure 12) secured as by means of bolts 34 to flanges 35 provided on the sections.

At the top of the boiler and directly above the combustion chamber A the sheathing 31*a* and casing 32*a* are of rectangular shape, so as to provide the rectangular gas space or chamber D. The products of combustion leave the combustion chamber through the annular top outlet G and enter the chamber D, and finally leave the chamber D for discharge into the stack through the offtake H.

The chamber D is provided with an upright inner wall 36 also of rectangular form in surrounding relation to the upper portion of the drum. A horizontal wall 37 extending inwardly from the lower end of the inner wall 36 to the drum is provided to confine the flow of the gases to the space D between the inner wall 36 and the outer wall formed by the sheathing 31*a*, in which space the superheater E and economizer F are located.

Referring now particularly to Figures 1, 4 and 5, fuel, preferably pulverized coal, is introduced into the combustion chamber A by means of a plurality of nozzles 38 arranged at evenly spaced intervals around the periphery of the chamber, the fuel being supplied to these nozzles from an annular chamber 39 around and outside of the furnace having an inlet, as indicated at 40 in Figure 4, for the fuel and primary air. The nozzles are positioned substantially tangentially so as to whirl the mixture around the chamber, and are also directed downwardly toward the bottom of the combustion chamber, it being noted that the jets from the nozzles adjacent the slag discharge openings 23 are directed toward the openings, as shown in Figure 5.

Secondary air is introduced at the nozzles, as illustrated in Figure 5, there being a continuous annular plenum chamber 41 around the furnace, to which the air is supplied by means of an inlet 42. A casing 43, opening into the combustion chamber, surrounds each nozzle 38 and is provided with openings 44 communicating with the annular chamber 41 so that the secondary air is introduced adjacent to the point of fuel introduction. Dampers 42*a* in the nature of air scoops are provided at the openings 44 to direct the air to the fuel nozzles.

The fuel and primary air are introduced at high velocities, say from 8000 to 9000 feet per minute, and since the streams are introduced tangentially and downwardly, a very high state of turbulence is set up with the result that combustion of the fuel is very rapid and the heat transfer per square foot is high because of the scrubbing action over the boiler tubes. Also, by directing the fuel downwardly toward the bottom of the furnace, molten slag is maintained on the bottom which catches the ash particles and melts them.

Referring now particularly to Figures 1 and 2, the superheater E is built in four sections, each of the same construction, preferably counterpart, and located around the sides of the rectangular chamber D. The tubes of the superheater are horizontally disposed and are arranged in vertical rows with their inlet ends 45 connected into inlet headers 46 and their outlet ends 47 connected into outlet headers 48, there being one inlet and outlet header for each section of the superheater. Steam is led from the steam space of the drum to the inlet headers 46 by means of steam pipes 49.

The econimizer F is also built in four sections of horizontally disposed tubes similar to those of the superheater, except that the economizer has more tubes or elements in height. The inlet ends 50 of the economizer tubes are connected into inlet headers 51 and the outlet ends 52 into outlet headers 53, there being one inlet and outlet header for each section of the economizer. Feed water is led to the inlet headers 51 by means of inlet pipes 54, and the heated feed water is led from the outlet headers of the economizer into the steam space of the drum by means of pipes 55.

The above construction of the economizer and superheater in sections enables them to be manufactured in the shop with the inlet and outlet headers attached for shipment in quarter parts, thus eliminating expensive field work and reducing replacement costs.

The pipes 55, after entering the drum, are bent downwardly as shown at 56, so as to deliver the water downwardly into a circular trough 57 adjacent its periphery, as indicated by the arrow 58 in Figure 1. The water then flows upwardly in the direction of the arrow 59, then over the rim 60, and thence downwardly as indicated by the arrow 61.

The steam discharged by the furnace tubes 16 and tubes 17 through the bends 22 (Fig. 1) passes into the outer annular space 61*b* where it is partially separated from the water and thence passes downwardly into the outer portion of the trough 57. Partition 65 seals the top of the annular space 61*b*. The feed water in said outer trough portion is depressed by the steam until both steam and water flow in the direction of arrows 58, 59 and 61 while thoroughly intermixing. While passing through the region shown by the arrow 61, most of the water follows the direction of the arrow 61 and separates from the steam while the remainder will be entrained by the then high velocity of the steam

and will pass with the steam upwardly into the central space 62 around which is arranged a dryer comprising a bundle of upright rods 63 of small diameter, arranged on relatively close centers and carried by upper and lower perforated plates 64 and 65 secured to the interior of the drum. The rods may be readily removed, rearranged or renewed.

The steam in passing through the maze of rods of the dryer impinges on the rods and gives up its moisture and impurities. The moisture and impurities find their way to the bottom of the rods, and the dried purified steam passes into the steam pipes 49 which lead to the inlet headers 46 of the superheater sections.

Referring now to the manner of supporting the boiler and other parts of the installation, it will be seen that the central upright drum is provided with a flange 66 at its lower portion which rests on structural members or legs 67, thereby giving bottom support to the drum and its boiler tubes. At the upper portion of the drum a plurality of supporting brackets 68 are provided which give support to the upper horizontal structural members indicated at 69, 70 and 71, in Figures 1 and 2. The superheater and economizer elements are suspended from the upper structural members as by means of suspension straps 72, so that the superheater and economizer receive their support from the drum without the necessity of outside supports.

The boiler casing is of light weight, and since the drum and boiler tubes receive their support from the bottom structural members 67 independently of the casing, it will be seen that the casing has only its own weight to support.

In erecting an installation, the preferred procedure would be to set the drum in place on the bottom members 67, then to position the upper horizontal members 69, 70 and 71 so as to be supported by the brackets 68, then to suspend the superheater and economizer elements from the horizontal members, and then to roll the boiler tubes into the drum. Next the sheathing and casings may be applied.

Assuming now that the enlarged portions of the drum are 54 inches in diameter, the middle portion 24 inches in diameter, the boiler tubes 3 inches in diameter and spaced approximately on 3½ inch centers, the inside diamter of the combustion chamber 7 feet 4 inches, the outside diameter 14 feet and the height 20 feet, and that the fuel and air are introduced at a velocity of 8000 to 9000 feet per minute through four burners, the boiler would have an output of approximately 100,000 pounds of steam per hour at 600 pounds pressure and 750 degrees total temperature.

I contemplate increasing the combustion rate to 200,000 or 300,000 B. t. u. per cubic foot, for example by utilizing oil for fuel, and in such case the furnace height would be considerably less. In instances where the furnace is so low in height that natural water circulation would be inadequate, I employ an automatic valve 72 in the lower enlarged portion 18 of the central drum, such as illustrated in Figure 13. The valve is mounted in the lower portion of the drum for up and down movement as by means of the parallel levers 73 pivotally connected to the drum at 74 and to the valve at 75. An annular seat 76 is provided for the valve, and as will be seen the valve closes upwardly and opens downwardly. The valve seat 76 is located somewhat above the point where the uppermost tube connections are made into the lower portion of the drum.

An inlet pipe 77 leads water from the space above the valve 72 to a circulating pump 78 and the water is discharged from the pump to space below the valve by means of the discharge pipe 79. It will thus be seen that when the valve is closed, water is circulated by means of the pump from the space above the valve to the space therebelow, and from thence the flow is into the inlet ends of the boiler tubes, thence upwardly through the tubes into the upper portion of the drum and thence downwardly in the drum.

When high capacities are desired the circulating pump is started and pressure is set up underneath the valve so that it moves upwardly to its closed position and seals off the lower part of the drum to force the water into the lower ends of the boiler tubes. When the boiler is operating at reduced rates, the pump is stopped and the valve moves downwardly to open position, whereby natural circulation takes place.

It will be seen from the foregoing that I have provided a high capacity boiler of simple construction having low draft losses, a relatively small number of boiler tubes all of the same diameter arranged so that the resistance to upward flow of water and steam is small, a central drum which acts as a downcomer for all of the boiler tubes and provides the minimum of resistance to down-flow of water, and one to which the application of forced circulation is a simple matter because all of the steam making tubes receive their water from a common drum.

It is also a simple matter to provide a gauge glass for the boiler by running a pipe 80 from the lower portion of the drum up alongside the outer wall tubes 17 and inside of the insulation, and thence outwardly at 81 just below the low water level for connection to the bottom of a gauge glass 82. A pipe 83 connects the top of the gauge glass with the top portion of the drum. By this arrangement the gauge glass connection is maintained at the same temperature as the water in the drum and since there is little or no steam present in the drum the two columns of water, in the drum and in the gauge line, are of equal unit weight. Thus the level in the glass and in the drum will be the same at all times.

A circular soot blower comprising a plurality of sections 84 having nozzles 85 is provided at the top of the furnace. The sections are made of tubing of relatively small diameter, whereby the amount of steam for blowing is relatively small. One section may be blown at a time, if desired.

In the modification illustrated in Figure 14 I have shown the inner wall tubes 16 bowed outwardly at 86 to extend somewhat over the upper portion of the annular combustion chamber, whereby additional convection surface is provided at the top of the combustion chamber. These bowed portions also act as expansion bends.

It is pointed out that the heat absorbing surface of the walls is of such capacity that the temperature of the gases to the convection tube portions 22 is never in excess of about 2000° F. and preferably about 1800° F.

When using pulverized coal for fuel, fused ash will adhere, more or less lightly, to the heat absorbing wall surface between the end of the flame and the tube portions 22. The degree of adhesiveness of the deposit will be greater at one zone than at another and the zones will approach or recede from the convection tube portions as the rate of combustion is altered. Close to the end

of the flame the ash may fuse sufficiently to cause it to flow down the tubes. At high ratings no appreciable thickness of slag deposits on the walls because the scrubbing action of the fuel and flame stream cuts the slag deposits.

The ash collects on the bottom of the furnace as liquid slag and is removed in liquid state through the slag discharge openings 23. Since some liquid slag will always be present even at extremely low rates of operation, flexibility of operation is ensured due to the heat stored up, and change in rate of operation will not entail detrimental results in combustion.

I claim:

1. A steam generator comprising upright drum means, upright boiler tubes connected at their upper and lower ends into said drum means and being grouped to provide inner and outer upright tubular walls of an annular combustion chamber in surrounding relation to said drum, a top gas outlet from said annular chamber, a superheater directly above said chamber subject to the flow of gases leaving said outlet, an economizer directly above said superheater, an offtake directly above said economizer, and means for introducing fuel into said chamber to be burned in space therein.

2. A steam generator comprising upright drum means, upright boiler tubes arranged in circular groups to provide an annular combustion chamber therebetween, said tubes being connected at their lower and upper ends into the lower and upper portions of said drum means respectively, an annular top outlet for said annular combustion chamber, a rectangular chamber above said annular combustion chamber to which the products of combustion pass by means of said annular top outlet, and a superheater in said rectangular chamber comprising four counterpart sections, one positioned along each wall of said rectangular chamber.

3. A steam generator comprising upright drum means, upright boiler tubes arranged in circular groups to provide an annular combustion chamber therebetween, said tubes being connected at their lower and upper ends into the lower and upper portions of said drum means respectively, an annular top outlet for said annular combustion chamber, a rectangular chamber above said annular combustion chamber to which the products of combustion pass by means of said annular top outlet, a superheater in said rectangular chamber comprising four counterpart sections, one positioned along each wall of said rectangular chamber, and an economizer in said rectangular chamber located above said superheater and of similar construction to the superheater.

4. A steam generator comprising upright drum means, upright boiler tubes arranged in circular groups to provide an annular combustion chamber therebetween, said tubes being connected at their lower and upper ends into the lower and upper portions of said drum means respectively, an annular top outlet for said annular combustion chamber, a rectangular chamber above said annular combustion chamber to which the products of combustion pass by means of said annular top outlet, and a superheater in said chamber comprising four counterpart sections of horizontally disposed superheater tubes connected into inlet and outlet headers, one section being positioned along each wall of said rectangular chamber.

5. A steam generator comprising upright drum means, upright boiler tubes arranged in circular groups to provide an annular combustion chamber therebetween, said tubes being connected at their lower and upper ends into the lower and upper portions of said drum means respectively, an annular top outlet for said annular combustion chamber, a rectangular chamber above said annular combustion chamber to which the products of combustion pass by means of said annular top outlet, and a superheater and superimposed economizer in said chamber, each comprising four counterpart sections of similarly horizontally disposed tubes connected into inlet and outlet headers with the economizer containing more tubes in height than the superheater, said sections of the superheater and economizer being arranged along the sides of said rectangular chamber.

6. A steam generator comprising an upright drum, a bottom support for said drum, upright boiler tubes arranged in circular groups to provide an annular combustion chamber therebetween, said tubes being connected at their lower and upper ends into the lower and upper portions of said drum respectively, a superheater chamber above said annular combustion chamber, a superheater in said chamber, and means for supporting said superheater from the upper portion of said drum.

7. A steam generator comprising an upright drum, a bottom support for said drum, upright boiler tubes arranged in circular groups to provide an annular combustion chamber therebetween, said tubes being connected at their lower and upper ends into the lower and upper portions of said drum respectively, a waste gas chamber above said annular combustion chamber, a superheater and economizer in said waste gas chamber, and means supporting said superheater and economizer from the upper portion of said drum.

8. A steam generator comprising an upright drum, upright boiler tubes connected at their lower and upper ends into the lower and upper portions of the drum respectively, said tubes being circularly arranged in inner and outer groups with an annular space therebetween constituting a combustion chamber, means intermediate the height of said outer group of tubes for tying them together including metallic positioning blocks and band means encircling said blocks and secured to the tubes.

9. A steam generator adapted to be operated with natural circulation for low capacities and forced circulation for high capacities comprising an upright drum, upright steam generating tubes connected at their lower and upper ends into the lower and upper portions of said drum respectively, said tubes being grouped to provide inner and outer upright walls of an annular combustion chamber in surrounding relation to said drum, said tubes constituting the entire steam generating surface of the boiler and said drum constituting the downcomer means for all of said tubes, valve means in the lower portion of said drum having a closed position in which the lower portion of the water space of the drum into which the lower ends of the steam generating tubes are connected is divided off from the remaining portion of the drum and an open position in which communication is established between said portions of the drum, a water circulating pump, an inlet connection from the water space above said valve to said pump, a discharge connection from said pump to the water space below said valve.

and means for mounting said valve to close when said pump is in operation and thereby effect forced circulation in the boiler, and to open when said pump is stopped and thereby effect natural circulation in the boiler.

10. A steam generator comprising upright drum means, upright boiler tubes connected at their lower and upper ends into the lower and upper portions of the drum respectively, said tubes being grouped to provide inner and outer upright tubular walls of an annular combustion chamber, means for introducing fuel into said chamber to be burned in space therein, and water gauge means comprising a gauge glass positioned to indicate the level of the water in the boiler from low to high levels, a connection from the lower portion of the drum to the bottom of said gauge glass, said connection being located for substantially its full length in close association with boiler tubes so as to be subject to the same temperature as said boiler tubes, and a connection from the top of said gauge glass to the upper portion of said drum.

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