Jan. 24, 1967 K. S. SVENDSEN 3,299,860

CIRCULATING SYSTEM FOR FORCED CIRCULATION STEAM GENERATOR

Filed Dec. 14, 1964 3 Sheets-Sheet 1

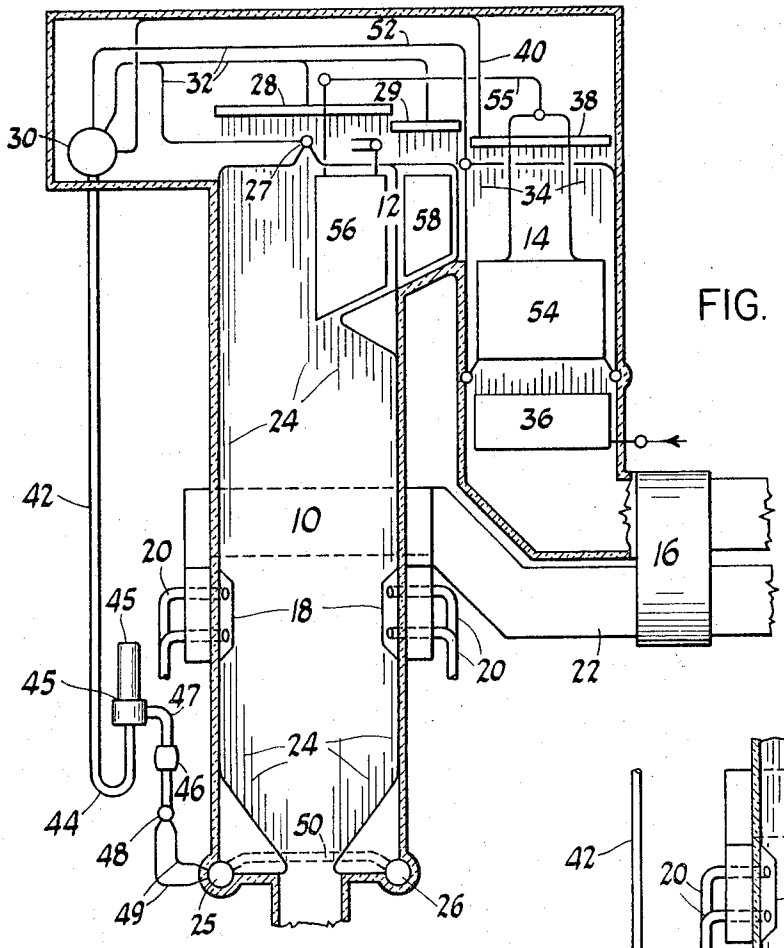

FIG. 1

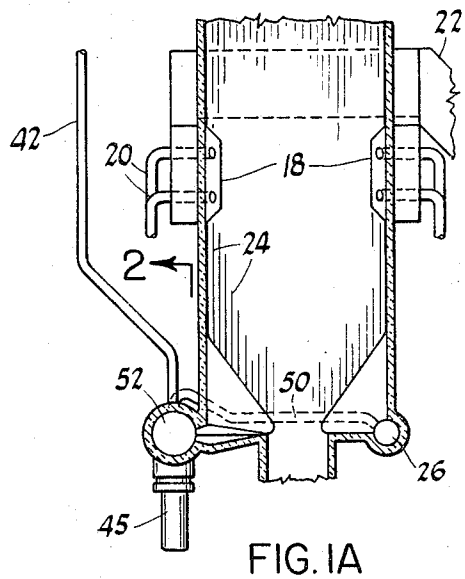

FIG. 1A

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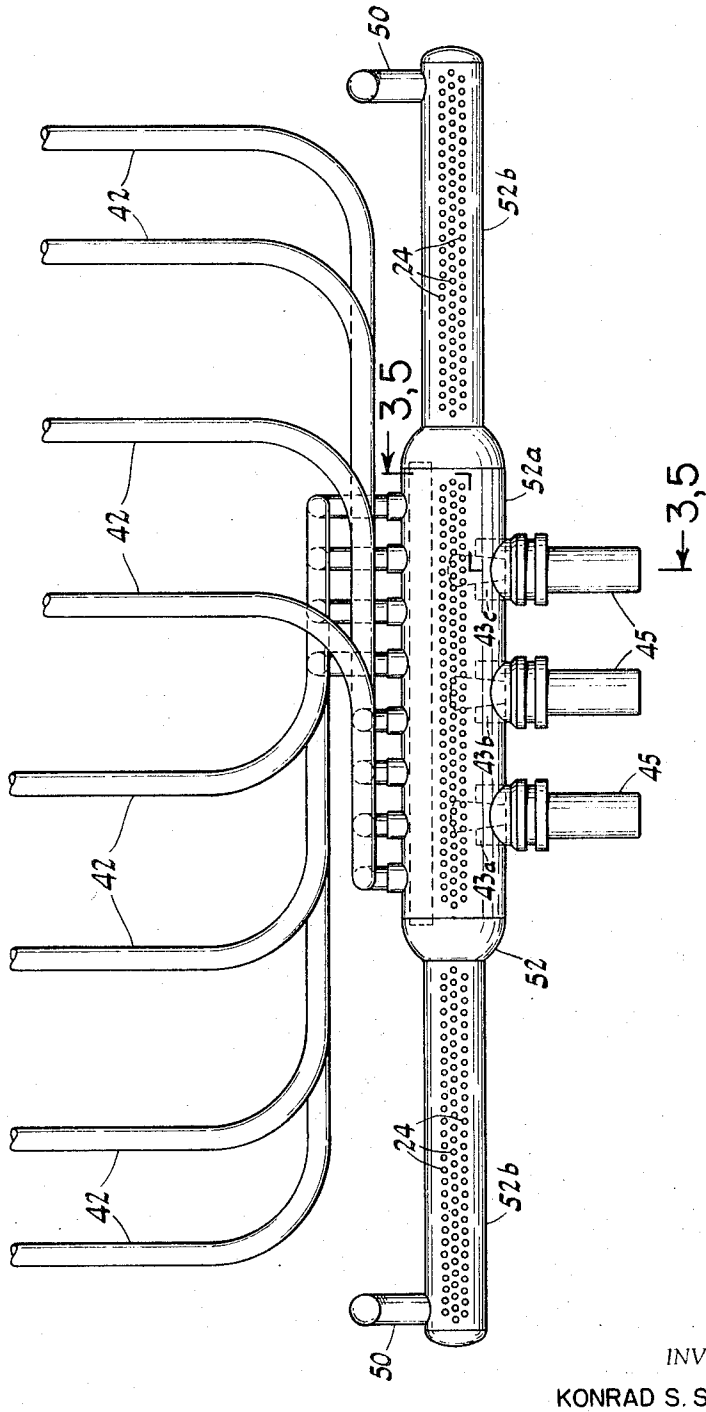

FIG. 2

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Filed Dec. 14, 1964 3 Sheets-Sheet 3

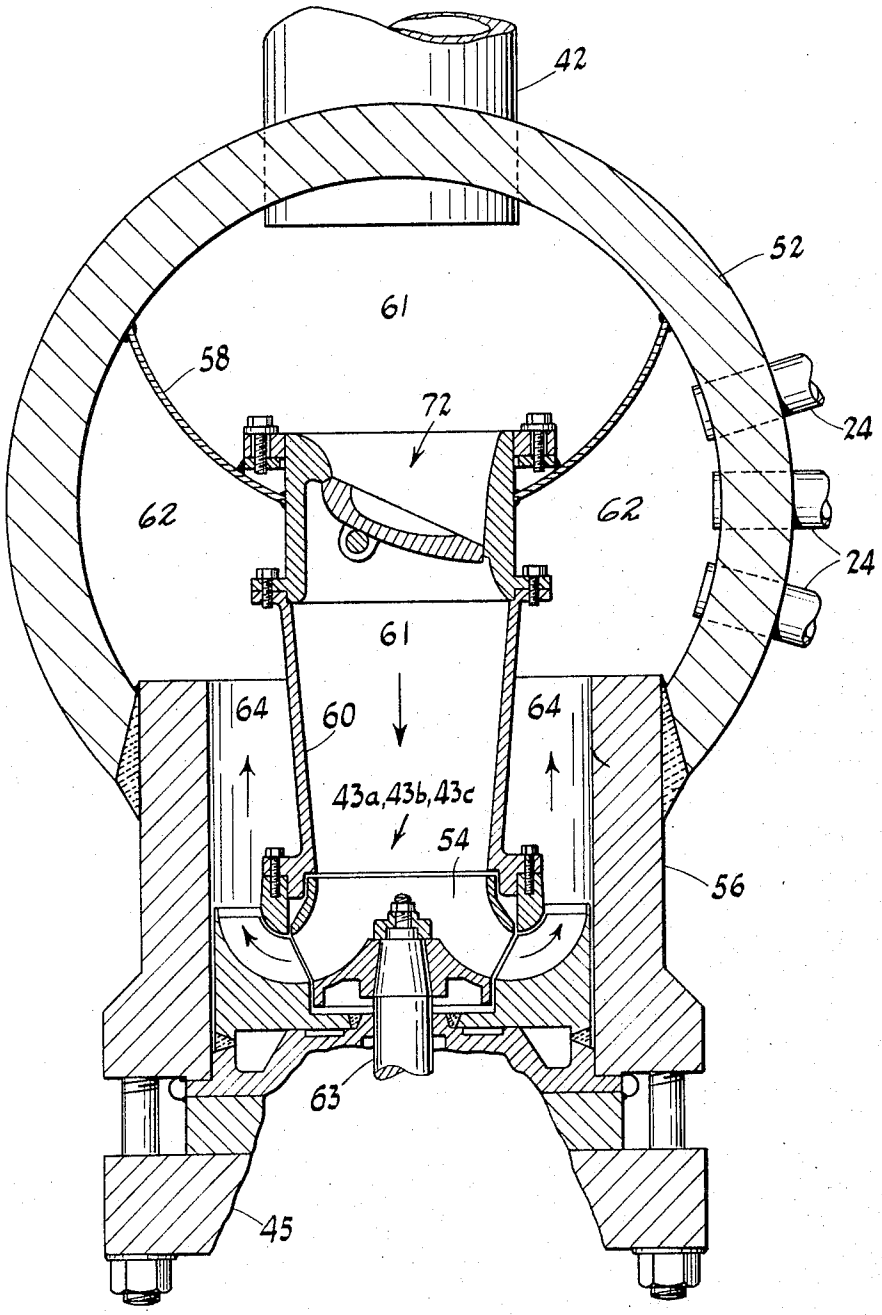

FIG. 3

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CIRCULATING SYSTEM FOR FORCED CIRCULATION STEAM GENERATOR

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2 Claims. (Cl. 122—406)

This invention relates to steam generating apparatus and has specific reference to steam generators of the high steam pressure forced circulation type.

By the term "forced circulation" in contrast to "natural circulation" is meant a steam generator having a positive or forced circulation of water through the various steam generating circuits, such forced circulation being established by one or several circulating pumps installed in the circulating circuit at suitable locations.

In modern high capacity steam generators producing one million or more pounds of steam per hour at high pressures, three or more large pumps as a rule are provided in the circulating circuits. Because of the high operating pressure (two thousand and more pounds per square inch) these pumps are of the canned or submerged type with driving means, such as electric motor, arranged above the pump housing and mounted with the pump rotor on a common vertical shaft. The accepted and conventional location of these pumps is in the vertical downcomer conduits between the steam and water drum located near the top of the steam boiler and the lower water wall headers or drum supplying the furnace walls with water. Such conventional positioning of the circulating pumps generally requires that the vertical downcomer conduits be provided with a hairpin loop or return bend leading up into the lower inlet end of the pump and motor set, and also must be provided with a second bend leading from the upper outlet of the pump downwardly into a lower distributing header. This double bend construction is not only very expensive but requires the use of large valuable boiler room space.

The present invention alleviates the above difficulties by combining the circulating pumps, return bends and necessary check valves with the lower water wall drum to form a single unitary facility, or in other words, by making the circulating pumps, pipe bends, etc. integral parts of the water wall drum.

It is accordingly a general object of the invention to provide an improved and more economical circulating system for large steam boilers by placing the circulating pumps including the inlet and outlet connections thereto and check valves inside the lower water wall header or drum.

A more specific object is to reduce the number of costly return bends in the downcomer lines of forced circulation boilers and reduce the boiler room space required for their installation.

Another object of the invention is to provide a forced circulation steam generator with an upper steam and water drum and a lower water wall drum, the latter serving as a housing for a multiplicity of circulating pumps, the drums and pumps being interconnected in such a manner as to interchangeably serve a plurality of downcomer conduits and steam generating circuits.

Other and further objects and advantages of my invention will become apparent from the following description of an illustrative embodiment thereof when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a diagrammatic vertical section of a modern high capacity, high pressure forced circulation steam generator equipped with circulating pumps which are conventionally located in the downcomer conduits leading from the top drum to the bottom header;

FIG. 1A is a lower portion of a diagrammatic vertical section of a steam generator similar to FIG. 1, but showing the circulating pumps integral with the lower water wall header or drum, in accordance with the present invention;

FIG. 2 is an enlarged front view along line 2—2 of FIG. 1A showing the water wall drum and pump combination together with the inlet and outlet connections thereto;

FIG. 3 is an enlarged section along line 3—3 of FIG. 2 through the drum and circulating pump, and showing a check valve being provided inside the drum in the suction duct leading to the pump rotor.

The illustrative steam generator benefitted

Referring now to the drawing, wherein like parts are designated by like reference characters, the high pressure, high capacity steam generator diagrammatically represented in FIG. 1 comprises a vertically disposed furnace chamber 10 of generally rectangular cross section. This furnace communicates at its upper end with a horizontal gas pass 12 which, in turn, communicates with the upper end of a vertical rear gas pass 14 leading to air preheater 16. Furnace 10, by way of example only, is disclosed as fired by a plurality of burners 18 that are supplied via conduits 20 with fuel in the form of pulverized coal from pulverizers, not shown. Preheated air is introduced under pressure by means of a suitable forced draft fan, not shown, which passes air through preheater 16 and ducts 22 and thence into the furnace at points surrounding burners 18, such introduction resulting in complete burning of the fuel. The hot combustion gases generated flow upwardly through furnace chamber 10, through horizontal pass 12 and downwardly through vertical rear pass 14, pass through air heater 16 and are discharged into the atmosphere, such as for example by way of an induced draft fan and stack, not shown.

The walls of furnace chamber 10 and those of horizontal pass 12 are lined with closely spaced fluid cooled tubes 24. These tubes communicate at their lower ends with water wall headers or drums 25, 26 and at their upper ends with headers 27, 28, 29 which, in turn, are connected to a steam and water drum 30 by tubes 32. The side walls of rear pass 14 are likewise lined with fluid cooled tubes 34 which originate in economizer 36 located in the rear pass, and which are connected to drum 30 by way of header 38 and pipe 40. Feedwater maintained under high pressure by means of a feed pump (not shown) is introduced into economizer 36, is heated therein and passes into drum 30 by way of header 38 and pipe 40, where it mixes with the recirculated water in the drum which water had already been heated to saturated temperature in the furnace tubes. The water then flows out of the drum 30 downwardly through vertical downcomers 42 into water wall headers 25, 26 thence upwardly through furnace tubes 24 and back to the drum 30 by way of headers 27, 28, 29 and tubes 32, thereby completing the recirculating circuit. The force required to circulate the water through the furnace tubes is produced by natural circulation and is supplemented by one or more circulating pumps 43 installed at the lower ends of downcomers 42, with these ends being shaped in the form of return bends 44. Each pump 43 is usually of the canned or submerged centrifugal type and is generally driven by an electric motor 45 on a vertical shaft. A check valve 46 is provided in the conduit 47 leading from the discharge side of circulating pump 43 to a distributing header 48. Rows of tubes 49 deliver the water from header 48 to water wall header 25 and to a crossover connection 50 leading to water wall header 26.

As the water rises in the furnace wall tubes 24 steam is produced and a mixture of steam and water enters

drum 30. A conventional steam and water separator (not shown) installed in drum 30 separates the water from the steam. The separated water is then mixed with the feedwater from the economizer and enters downcomers 42 as earlier herein described. The steam passes through tubes 52 to a low temperature superheater 54 located in rear pass 14. After having been heated therein to a desired temperature the steam is conducted through pipe 55 to a high temperature superheater 56 located in horizontal gas pass 12, and then to a point of use such as a steam turbine generator (not shown). Other heating surfaces may be placed in the path of the combustion gases such as steam reheater 58.

The improved circulating system

The hereinabove described apparatus as illustratively shown in FIG. 1 represents a typical steam generator to which the present invention can be applied with great benefit. More specifically, my invention is concerned with that portion of the circulating system which comprises the downcomers 42 leading from drum 30, including the return bend portion 44 of downcomers 42, the circulating pumps 43, bend pipe section 47, check valve 46, distributing header 48, tubes 49 and water wall header 25.

In accordance with my invention the manner in which these individual parts of the circulating system are combined into a unified whole is illustrated in FIG. 1A. A lower water wall drum 52 is organized in such a manner as to receive a plurality of circulating pumps as integral parts thereof with the downcomers 42 directly connected to this drum 52. In accordance with the invention the return bends 44 are eliminated and check valves 46 are placed within the interior of drum 52. Distributing header 48 and connecting tubes 49 are likewise eliminated, with tubes 24 and crossover conduit 50 directly communicating with drum 52. A considerable economic advantage is derived from this unified arrangement. Also, important savings in boiler room space and simplicity in supporting structure are realized. Furthermore, the proposed unified arrangement decreases flow losses in the recirculating system and results in improved pump efficiency.

Considering now the construction of drum 52 in detail, attention is first directed to FIG. 2, showing an elevational view of the drum and pump system. As illustratively shown, drum 52 comprises three main portions, a center portion 52*a* and two end portions 52*b*. In the embodiment shown in FIG. 2, three circulating pumps 43*a*, 43*b* and 43*c* are incorporated in the wall of drum portion 52*a*, with eight downcomer pipes 42 entering this drum portion 52*a* at the top thereof. The end portions 52*b* together with center portion 52*a* are organized to receive the lower ends of water wall tubes 24 and the ends of crossover conduits 50 for supplying water wall header 26 (see FIG. 1A). Of the recirculating pumps, only the electric motors 45 extend from the drum housing with the pump rotors 54 housed in nozzles 56 which are part of the drum wall as shown in FIGS. 3 and 4.

Referring now to FIG. 3, the interior space of drum 52 is divided into two portions by a curved division plate 58 and pump inlet conduits 60. One of these two portions, the inlet portion or space 61, is defined by the concave side of plate 58, by an upper portion of the drum wall and by the interior wall of conduits 60. The other portion of the drum interior, the outlet portion or space 62, comprises the remaining space of the drum and is operatively separated by the pump rotor 54 from the inlet portion 61.

In operation, water enters inlet portion 61 by way of conduits 42, and passes through conduit 60 into rotor 54. With this rotor being driven by an electric motor mounted on rotor shaft 63 the water is forced out of the rotor by centrifugal force and passes through outlet duct 64.

The end of each duct 60 is organized to receive check valve 72 of conventional design which during operation is held open by the pump inlet suction and which will close during emergency conditions when the pump is inoperative and when the pressure in the discharge space 62 exceeds the pressure in the suction space 61 of the drum.

Having passed through outlet ducts 64, the water enters outlet space 62 which communicates with the outlet or discharge conduits 64 of all three pumps 43*a*, 43*b* and 43*c*. Outlet space 62 extends throughout the three portions 52*a*, 52*b* of drum 52. This space also communicates with a plurality of water wall tubes 24 originating in drum 52 as shown in FIGS. 1A and 2, and with crossover conduits 50 through which water passes to water wall header 26.

Advantages and summary

From the foregoing it will be seen that I have provided a forced circulation steam generator with a circulating system that offers substantial economic advantages with respect to original capital investment, cost of maintenance, space requirements, and improved efficiency of operation. Stated more precisely, these advantages are achieved by eliminating return bends 44, outlet bends 47, header 48 and tubes 49 (see FIG. 1). Thus, in accordance with the invention the functions of these elements are now being performed by drum 52, or more specifically by the inlet space 61 thereof, including inlet conduit 60, and by outlet space 62 thereof including outlet conduit 64 (see FIGS. 3 and 5). Since these conduits are now located inside drum 52 and in a pressurized zone, it is unnecessary to design these elements for maximum operating pressure, as heretofore required, thereby securing a substantial saving in cost. Furthermore, inlet space 61 as defined by division plate 58, and with which all three pumps and all downcomers 42 now communicate, permits water to enter any one of the pumps from all the downcomers regardless of which pump is in operation. Furthermore, the invention permits considerable savings in the cost of check valves 46 which now are located inside drum 52 and within a pressurized zone. In addition, because of the greatly simplified construction of my inventive organization the flow losses in the recirculation circuit are reduced a substantial amount. Also, a desirable increase in pump efficiency and a saving in boiler room space is achieved which contributes measurably to the economic and structural advantages of my invention.

While I have shown and described one preferred embodiment of my improved circulating system and have disclosed same as being applied to a forced circulation steam generator of a practical design, it is to be understood that such showing and application are illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. I therefore do not wish to be limited to the precise details set forth but desire to avail myself of such changes as fall within the purview of my invention.

I claim:

1. In a forced circulation boiler, in combination a circulation drum having a division wall dividing the drum into a suction manifold and a discharge manifold; a multiplicity of steam generating tubes located exteriorly of said drum; a multiplicity of circulation pumps being integral parts of the wall of said drum and having suction sides and discharge sides effectively located within said discharge manifold; said suction manifold having a plurality of inlet openings and a plurality of outlet openings; first conduit means for connecting the inlet openings of said suction manifold with the outlets of said tubes; second conduit means for connecting each of the outlet openings of said suction manifold with the suction side of one of said circulation pumps; said discharge mani-

fold having a plurality of outlet openings and a plurality of inlet openings, with the inlet openings of said discharge manifold being identical with the outlet openings of said suction manifold, third conduit means for connecting said discharge manifold outlet openings with the inlet openings of said tubes; fourth conduit means for connecting the discharge sides of said circulation pumps with the outlet openings of said discharge manifold; and check valves included in said second conduit means organized to shut off reverse flow through any pump which may be inoperative.

2. The combination as defined in claim 1, wherein said circulation drum has an elongated cylindrical shape with said division wall extending lengthwise at least through a portion of the drum.

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