March 5, 1935. H. J. KERR 1,992,955

STEAM BOILER

Original Filed Feb. 4, 1929 3 Sheets-Sheet 1

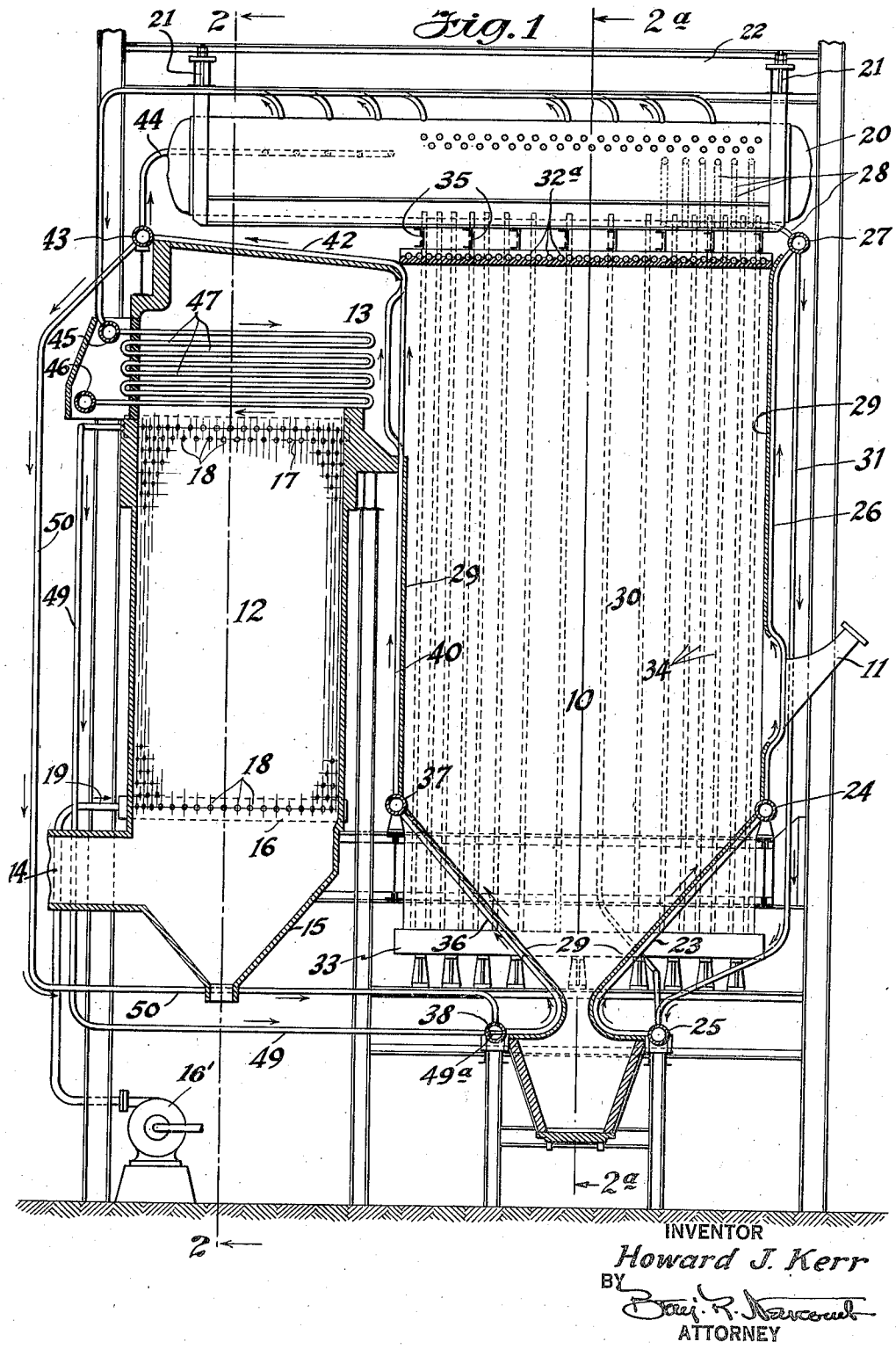

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Fig. 2

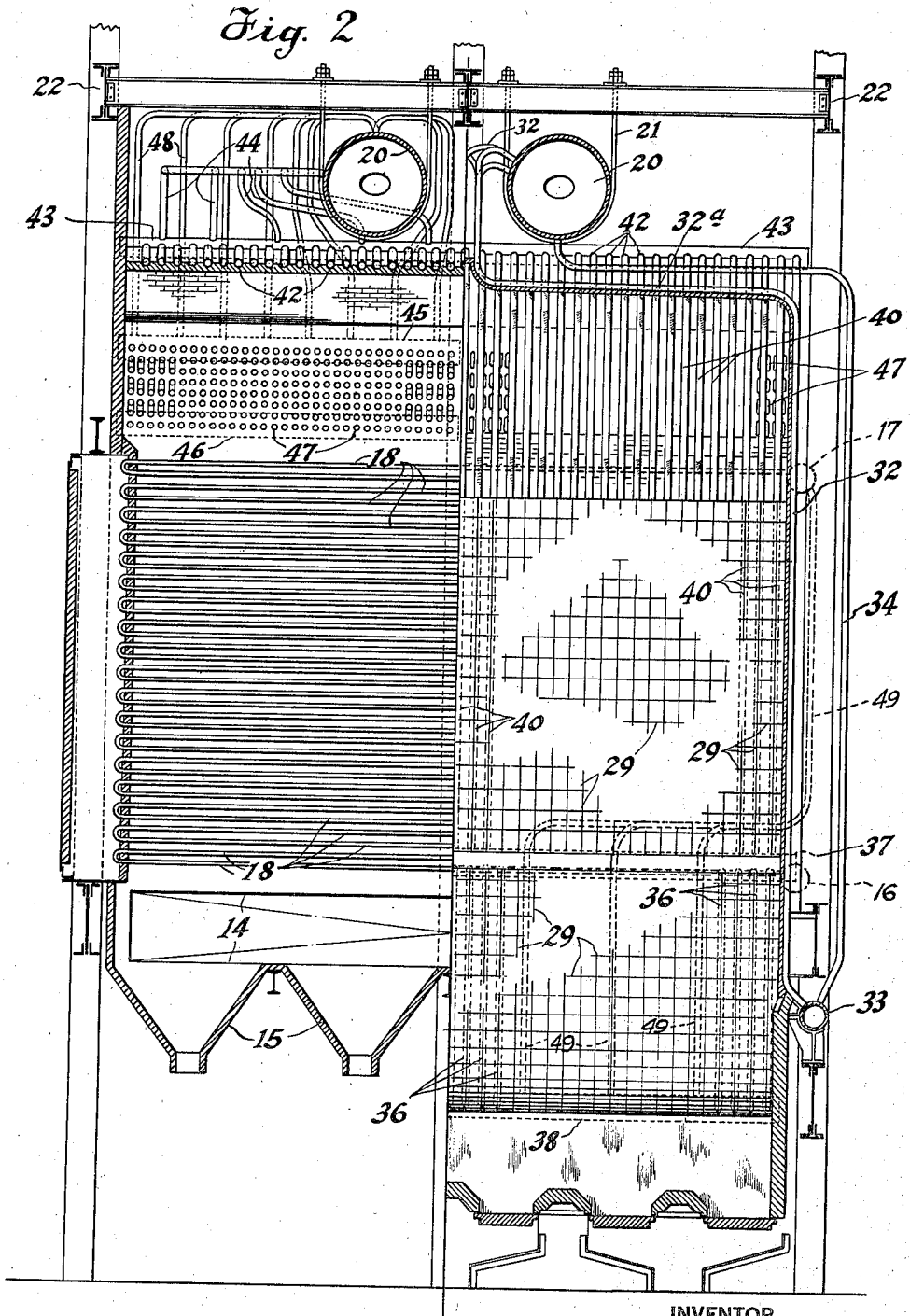

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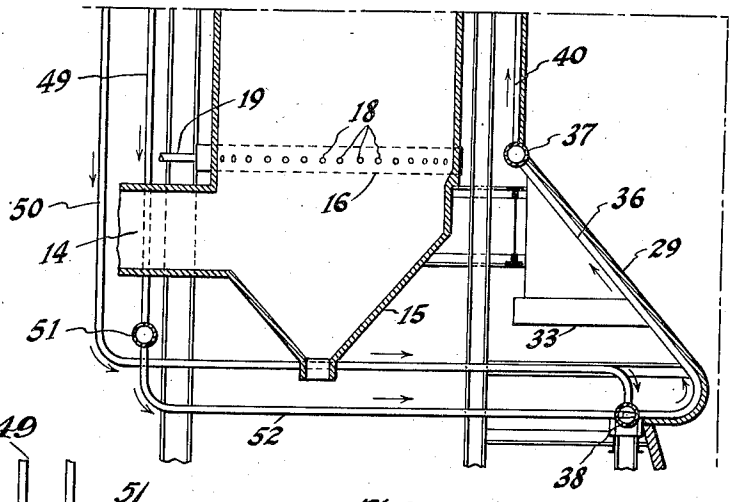
Fig. 3



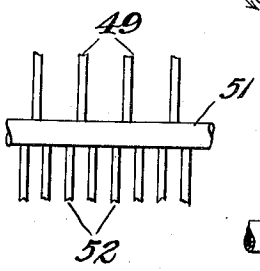


Fig. 6.

Fig. 4

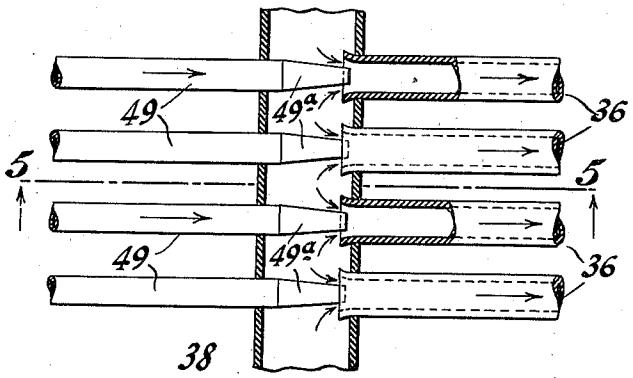
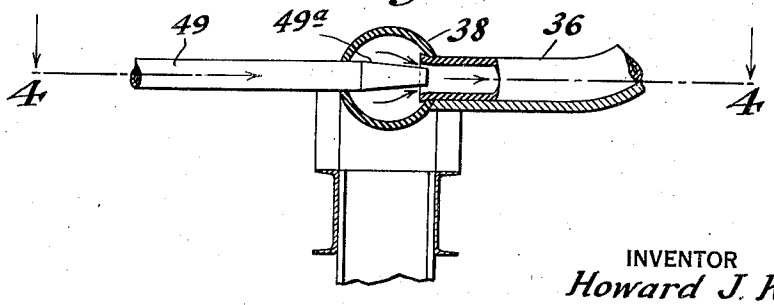


Fig. 5



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UNITED STATES PATENT OFFICE

1,992,955

STEAM BOILER

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Original application February 4, 1929, Serial No. 337,295. Divided and this application October 7, 1932, Serial No. 636,649

13 Claims. (Cl. 122—235)

My present invention relates to a method of and apparatus for generating steam at high pressures in large capacity steam generating units.

The general object of my invention is the provision of an improved method of and apparatus for generating steam at high pressures and in amounts substantially in excess of those usually attained in modern steam generating units with corresponding rates of heat input. A more specific object is the provision of a steam boiler in which substantially all of the steam generation is effected in steam generating elements absorbing heat by radiation from the combustion chamber. A further specific object is the provision of a steam boiler having a forced flow fluid heating section and one or more natural circulation steam generating sections and direct connections between the forced flow section and one or more of the natural circulation sections to accelerate the fluid circulation in the natural circulation section or sections so connected.

The various features of novelty which characterize my invention are pointed out with particularly in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described preferred embodiments of my invention.

Of the drawings,

Fig. 1 is a sectional elevation of a steam boiler constructed in accordance with my invention;

Fig. 2 is a vertical section through the boiler, the left half being taken on the line 2—2 and right half on the line 2A—2A of Fig. 1, certain connections being omitted for the sake of clarity;

Fig. 3 is a partial view similar to Fig. 1, illustrating a modified form of connection between the sections;

Fig. 4 is a horizontal section through one of the headers taken on the line 4—4 of Fig. 5; and

Fig. 5 is a section on the line 5—5 of Fig. 4.

Fig. 6 is a plan view of a modified arrangement of a detail of construction.

The apparatus embodying my invention illustrated in the drawings includes a furnace combustion chamber 10 into which fuel is introduced and burned by suitable fuel burning means, such as powdered coal burners 11 located in the front wall thereof. A vertical flue 12 is formed at the rear of the combustion chamber with its upper end communicating therewith through an outlet 13 in the upper rear portion of the combustion chamber. A stack connection 14 for waste gases is provided at the lower portion of the flue 12 beyond soot and dust hoppers 15.

The fluid heating surface of the boiler advantageously includes an economizer positioned in the flue 12 and comprising an inlet header 16 adjacent the bottom of the flue, and an outlet header 17 adjacent the top of the flue connected by a series of return bend tubes 18. The inlet header 16 is connected to a suitable feed pump 16' through a supply connection 19. A pair of steam and water drums 20 is symmetrically arranged longitudinally of the boiler adjacent the longitudinal center line thereof, extending over both the combustion chamber 10 and flue 12. The drums 20 are separately supported by straps 21 from cross-beams 22.

In the present construction substantially all of the steam is generated in heating surface arranged for the absorption of radiant heat from the combustion chamber 10. This heating surface includes a row of tubes 23 extending along an inclined bottom section of the front wall of the boiler and having their upper and lower ends connected respectively to headers 24 and 25. A row of tubes 26 extends upwardly along the front wall of the combustion chamber to an upper header 27, which is connected to the steam spaces of the drums 20 near the front end thereof by tubes 28. The rows of tubes 23 and 26 are preferably covered with refractory material 29. A natural circulation in this furnace wall section is established by tubes 30 extending from the water spaces of the drums 20 to the bottom header 25. Recirculation tubes 31, on the outside of the combustion chamber, preferably connect the headers 27 and 25.

Each side wall of the furnace is similarly provided with a row of closely spaced tubes 32 leading from a horizontally disposed bottom header 33 upwardly to the upper end of the combustion chamber, and having inclined portions 32^a lining the roof of the chamber, as shown in Fig. 2, and thence connected to the drums 20 above the water level therein. To equalize conditions in the two drums, some of the tubes 32 of each side wall are advantageously connected into the drum for the opposite side. The side wall tubes 32 are preferably covered with refractory material 29 in the same manner as the front wall tubes. A plurality of tubes 34 connects the water space of each drum 20 to the header 33 on the same side of the combustion chamber. The roof portions 32^a of the tubes 32 may be supported from above by suitable supports 35.

The fourth or rear wall of the combustion chamber, which in operation is usually subjected to more intense heating effects than the other walls of the chamber, has its sloping bottom portion provided with a row of tubes 36 similar in formation to the tubes 23, and connected at their upper and lower ends, respectively, to headers 37 and 38. A single row of closely spaced tubes 40 extends upwardly from the header 37 along the rear wall of the combustion chamber to the rear side of the tubes 32 the portion of alternate tubes extending across the gas outlet 13 being bent as indicated to facilitate the passage of heating gases between the combustion chamber 10 and flue 12. The tubes 40 have rearwardly inclined portions 42 connected to a horizontally disposed header 43, which in turn is connected to the steam spaces of the drums 20 by tubes 44 distributed along the header and drums. The portions of the tubes 40 not extending across the outlet 13 are protected from the heat of the combustion chamber by a refractory covering 29.

A superheater formed in two side-by-side sections is advantageously located at the upper end of the flue 12 at the rear of the gas outlet 13, each section comprising inlet and outlet headers 45 and 46 respectively, connected by a series of return bend tubes 47. The inlet and outlet headers of the adjacent sections are preferably horizontally aligned, each extending approximately half way across the setting, as shown in Fig. 2. Each superheater section is connected to the corresponding drum 20 by tubes 48, having their ends uniformly spaced along the corresponding drum 20 and header 45. The upper portions of the tubes 40 advantageously shield the superheater tubes from the radiant heat of the combustion chamber. Each outlet header 46 is connected to a steam main in the usual manner.

A rapid fluid circulation is maintained through the rear wall tubes 36 and 40 by connecting the outlet end of the economizer thereto. The economizer outlet header 17 is connected to a row of tubes 49, which pass externally of the boiler into the header 38. The ends of the tubes 49 entering the header are tapered to form nozzles 49^a, which extend into the lower end of the tubes 36, as shown in Figs. 4 and 5. The number of tubes 49 is preferably the same as the number of tubes 36, so that each tube 36 will receive a high velocity stream of water, or steam and water, depending upon whether the economizer is operating under non-steaming or steaming conditions. The cross-sectional areas of the tubes 36 and 40 are preferably proportioned to permit the use of recirculation tubes 50 between the headers 43 and 38.

With the steam boiler constructed as described, the feed water is delivered to the economizer inlet header at the desired pressure, and at a rate dependent upon the boiler load and the desired fluid conditions in the economizer, which may be steaming or non-steaming as condition may make desirable. The fluid leaving the economizer outlet header is discharged through the nozzles 49^a into the tubes 36 passing upwardly through the rear wall tubes 36 and 40 in which a portion of the water is evaporated. The steam and water mixture entering the header 43 passes through the tubes 44 into the drums 20, while some of the water is returned to the header 38 through the tubes 50, providing a natural circulation in the tubes 36 and 40. The natural circulation through the tubes 36 and 40 will be considerably accelerated by the described connection of the economizer thereto. The front and side wall tubes form natural circulation steam generating sections to which water is supplied by the tubes 30 and 34 respectively, from the water spaces of the drums 20, and the mixtures of steam and water from these sections are discharged into the steam space of the steam and water drum or drums connected thereto. The steam so generated and collecting in the drum 20, is superheated in the tubes 47 before delivery to the point of steam utilization.

The required supply of heat for effecting the described steam generation is delivered to the combustion chamber by the fuel discharged through the burners 11 and burned in the combustion chamber. The products of combustion from the combustion chamber pass across the upper end portions of the tubes 40 and downwardly through the flue 12, contacting successively with the superheater and economizer before leaving through the gas outlet 14.

The modification illustrated in Fig. 3 differs from the construction shown in Fig. 1, in that the tubes 49 instead of directly entering the header 38 are connected to an intermediate header 51, from which a row of tubes 52 extend into the headers 38. The ends of the tubes 52 are formed and arranged similarly to the tubes 49 in Figs. 4 and 5. The use of the distribution header 51 permits the use of a smaller number of the long tubes 49. The construction and mode of operation is otherwise identical.

While in accordance with the provisions of the statutes I have illustrated and described herein the best forms of my invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

The subject matter disclosed and claimed herein is disclosed but not claimed in my copending application, Serial No. 337,295, filed Feb. 4, 1929, of which this application is a division.

I claim:

1. A steam boiler comprising a furnace wall section including spaced headers, wall tubes connecting said headers and recirculator tubes externally connecting said headers, and a forced flow economizer having a plurality of tubes connected to the outlet end thereof and arranged to discharge into the lower ends of corresponding wall tubes.

2. A steam boiler comprising a steam and water drum, a furnace wall steam generating section connected to said drum and including spaced headers, wall tubes connecting said headers and recirculator tubes connecting said headers, and a forced flow economizer having a plurality of nozzle-ended tubes connected to the outlet end thereof and arranged to enter the lower ends of corresponding wall tubes.

3. A steam boiler comprising walls forming a combustion chamber, fuel burner means on one wall of said chamber, groups of steam generating tubes adjacent the walls of said chamber, a heating gas flue at the rear of said chamber and opening to the upper portion thereof, a steam and water drum, means connecting said groups of steam generating tubes to said drum, and a forced flow economizer positioned in said flue and having a plurality of nozzle-ended tubes connected to the outlet end thereof and arranged to enter the

lower ends of the tubes of one of said groups.

4. A steam boiler comprising a steam and water drum, furnace wall steam generating tubes connected to said drum and having their inlet ends connected along a header, means for supplying water to said header, and a forced flow economizer section, a plurality of tubes arranged to discharge into the inlet ends of corresponding furnace wall tubes, a header connected to the opposite ends of said discharge tubes, and tubes lesser in number than said discharge tubes connecting said last mentioned header to the outlet end of said economizer.

5. In a steam boiler having all of its steam generated in furnace wall tubes, drums affording a steam space and a water space, separate natural circulation steam generating circuits including furnace wall tubes, separate connections for each circuit with the steam space and the water space, a natural circulation economizer circuit including furnace wall tubes and recirculator tubes unconnected with the water space, a header for connecting the economizer furnace wall tubes and the recirculator tubes at the ends of the wall tubes, means for connecting the header to the drum, a forced flow once-through economizer section constructed and arranged to discharge into the economizer wall tubes in high velocity streams so as to induce an increase of flow velocity in the natural circulation economizer section, a burner located between the separate steam generating circuits and causing combustion gases to be directed toward the wall tubes of the economizer circuit, a flue for the forced flow economizer section, and means directing the furnace gases across and between portions of the economizer wall tubes to the flue whereby the economizer wall tubes are convection heated by the gases.

6. In a steam boiler, a steam and water drum, a furnace fired by a burner in one wall, wall cooling tubes at the opposite side of the furnace and subjected to heat from the burner, the lower portions of the tubes being subjected to radiant heat, an upper header connected to the upper ends of the wall tubes, and a lower header connected to the lower end of the wall tubes, recirculators connecting the upper and lower headers and shielded from the heat of the furnace and forming with the headers and the wall tubes a natural circulation circuit, means for connecting the upper header with the steam space of the drum, a flue receiving the furnace gases, means for causing the furnace gases to contact with and pass between the upper portions of the wall tubes while proceeding to the flue, a fluid heat exchange device comprising tube sections extending across the flue, means for connecting the tube sections to provide for a series flow of fluid therethrough, means forcing water through the heat exchanger, discharge tubes receiving fluid flowing from the heat exchanger and arranged to direct their flows into the lower ends of the wall tubes to thereby increase the flow in the natural circulation circuit, and a natural circulation steam generating section connected to the drum and including furnace wall tubes.

7. In a steam boiler, a steam and water drum, a furnace fired by a burner at one side of the furnace, wall cooling tubes at the opposite side of the furnace and subjected to heat from the burner, the lower portions of the tubes being subjected to radiant heat, an upper header connected to the upper ends of the wall tubes, and a lower header connected to the lower ends of the wall tubes, tubes connecting the upper header with the lower part of the steam space of the drum, recirculators connecting the upper and lower headers and shielded from the heat of the furnace and forming with the headers and the wall tubes a natural circulation circuit, a flue receiving the furnace gases, the upper portions of some of the wall tubes being bent out of alignment with their lower portions to decrease draft loss at the entrance to the flue, means for causing the furnace gases to contact with and pass between the upper portions of the wall tubes before proceeding to the flue, a forced flow economizer including tube sections extending across the flue, means for connecting tube sections to provide for a series flow of water therethrough, means forcing water through the economizer, discharge tubes receiving fluid flowing from the economizer and arranged to direct their flows into the lower ends of the wall tubes to thereby increase the flow in the natural circulation circuit, and a natural circulation steam generating section connected to the drum and including furnace wall tubes.

8. In a steam boiler having substantially all of its steam generated in furnace wall tubes, a drum affording a steam space and a water space, separate natural circulation steam generating circuits including furnace wall tubes, separate connections with the steam space and the water space for each circuit, an additional natural circulation circuit including furnace wall economizer tubes and recirculator tubes unconnected with the water space, a header for connecting the economizer furnace wall tubes and the recirculator tubes at the ends of the wall tubes, means for connecting the header to the drum, a forced flow once-through economizer section having nozzle ended tubes as outlets extended into the economizer wall tubes so as to create an induce flow in the additional natural circulation circuit, a burner located between the separate steam generating circuits and causing combustion gases to be directed toward the wall tubes of the additional circuit, a flue for the forced flow economizer section, and means directing the furnace gases across and between portions of the economizer wall tubes to the flue whereby the economizer wall tubes are convection heated by the gases.

9. In a steam boiler, a steam and water drum, a furnace fired by a burner at one side of the furnace, wall cooling tubes at the opposite side of the furnace and subjected to heat from the burner, the lower portions of the tubes being subjected to radiant heat, an upper header connected to the upper ends of the wall tubes, and a lower header connected to the lower ends of the wall tubes, tubes connecting the upper header with the steam space of the drum, recirculators connecting the upper and lower headers and shielded from the heat of the furnace and forming with the headers and the wall tubes a natural circulation circuit, a flue receiving the furnace gases, the spacing of the wall tubes being increased at their upper portions which extend across the flue entrance, means for causing the furnace gases to contact with and pass between the upper portions of the wall tubes before proceeding to the flue, a forced flow economizer including tube sections extending across the flue, means for connecting the tube sections to provide for a series flow of water therethrough, means forcing water through the economizer, discharge tubes receiving water flowing from the economizer and arranged to direct their flows

into the lower ends of the wall tubes to thereby increase the flow in the natural circulation circuit, and a natural circulation steam generating section connected to the drum and including furnace wall tubes.

10. In a steam boiler and furnace organization, a row of furnace wall tubes, a forced-flow economizer, a first header to which the wall tubes are directly connected, a second header receiving the discharge from the economizer, intermediate tubes directly connected to the first header with a spacing approximately equal to that of wall tubes and having their ends within the wall tubes so as to be discharging fluid into the wall tubes in high velocity flow-inducing streams, economizer discharge tubes connected to the second header with a spacing different from that of the intermediate tubes, the number of discharge tubes being unequal to the number of intermediate tubes.

11. In a steam boiler and furnace organization, a row of furnace wall tubes, a forced flow economizer, a first header to which the wall tubes are directly connected, a second header receiving the discharge from the economizer, nozzle ended tubes directly connected to the first header with a spacing approximately equal to that of wall tubes and discharging fluid into the wall tubes in high velocity flow-inducing streams, economizer discharge tubes connected to the second header with a spacing greater than that of the nozzle ended tubes.

12. In a steam boiler and furnace organization, a row of furnace wall tubes, a forced flow economizer, a first header to which the wall tubes are directly connected, a second header receiving the discharge from the economizer, nozzle ended tubes directly connected to first header with a spacing approximately equal to that of wall tubes and discharging fluid into the wall tubes in high velocity flow-inducing streams, economizer discharge tubes connected to the second header with a spacing different from that of the nozzle ended tubes, the number of discharge tubes being unequal to the number of nozzle ended tubes.

13. In a steam boiler and furnace organization, a row of furnace wall tubes, a forced flow economizer, a first header to which the wall tubes are directly connected, a second header connected to the outlet of the economizer, nozzle ended tubes directly connected to the first header with a spacing approximately equal to that of wall tubes and with their ends within the wall tubes to discharge fluid into the wall tubes in high velocity flow-inducing streams, economizer discharge tubes connected to the second header with a spacing greater than that of the nozzle ended tubes, the number of discharge tubes being unequal to the number of nozzle ended tubes.

HOWARD J. KERR.

CERTIFICATE OF CORRECTION.

Patent No. 1,992,955. March 5, 1935.

HOWARD J. KERR.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 15, claim 5, for "drums" read a drum; and second column, line 40, claim 8, for "induce" read induced; page 4, second column, line 8, claim 12, before "first" insert the word the; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of June, A. D. 1935.

(Seal)

Leslie Frazer
Acting Commissioner of Patents.