Nov. 4, 1947. E. G. BAILEY 2,429,976

VAPOR GENERATOR

Filed March 22, 1944 3 Sheets-Sheet 1

Fig. 1

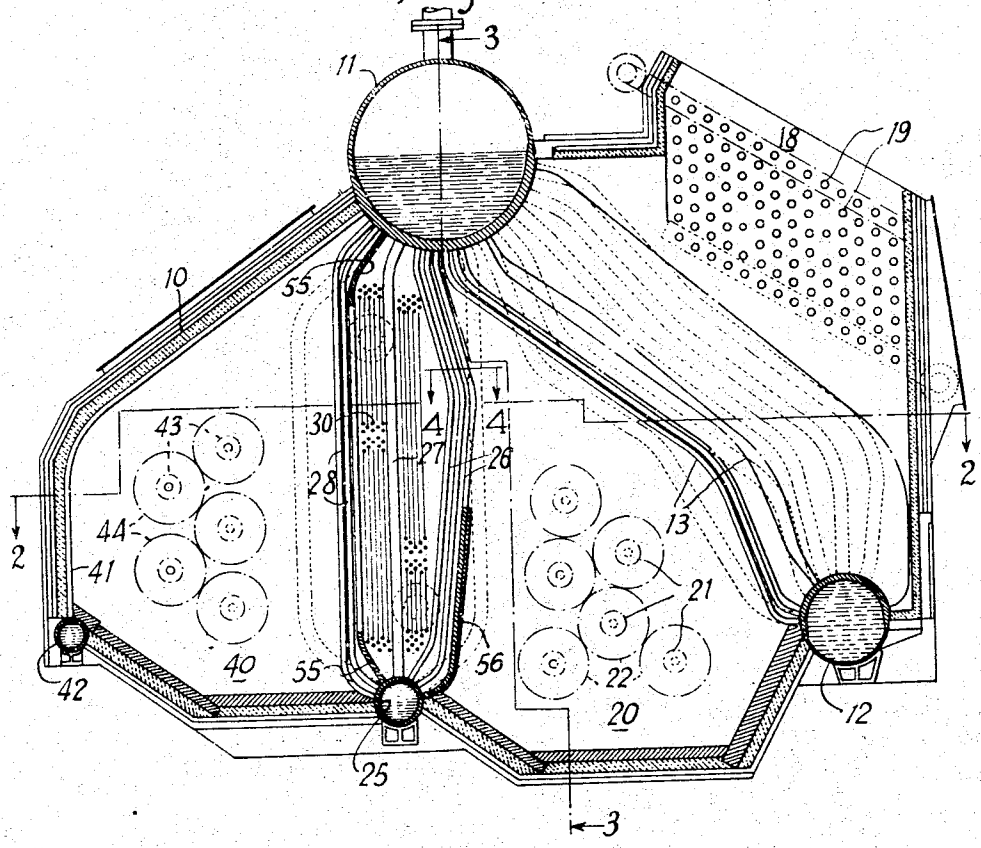
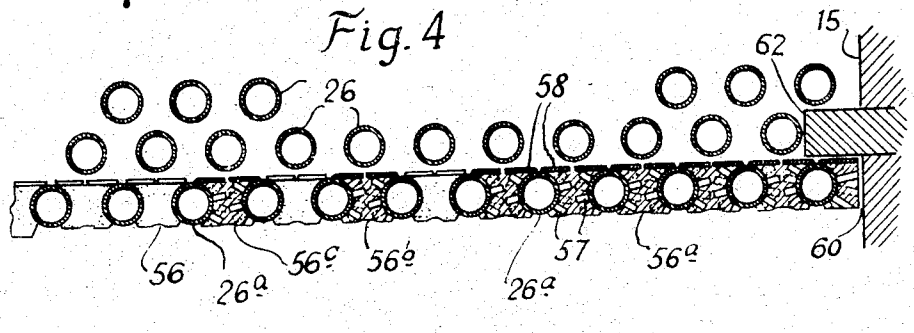


Fig. 4



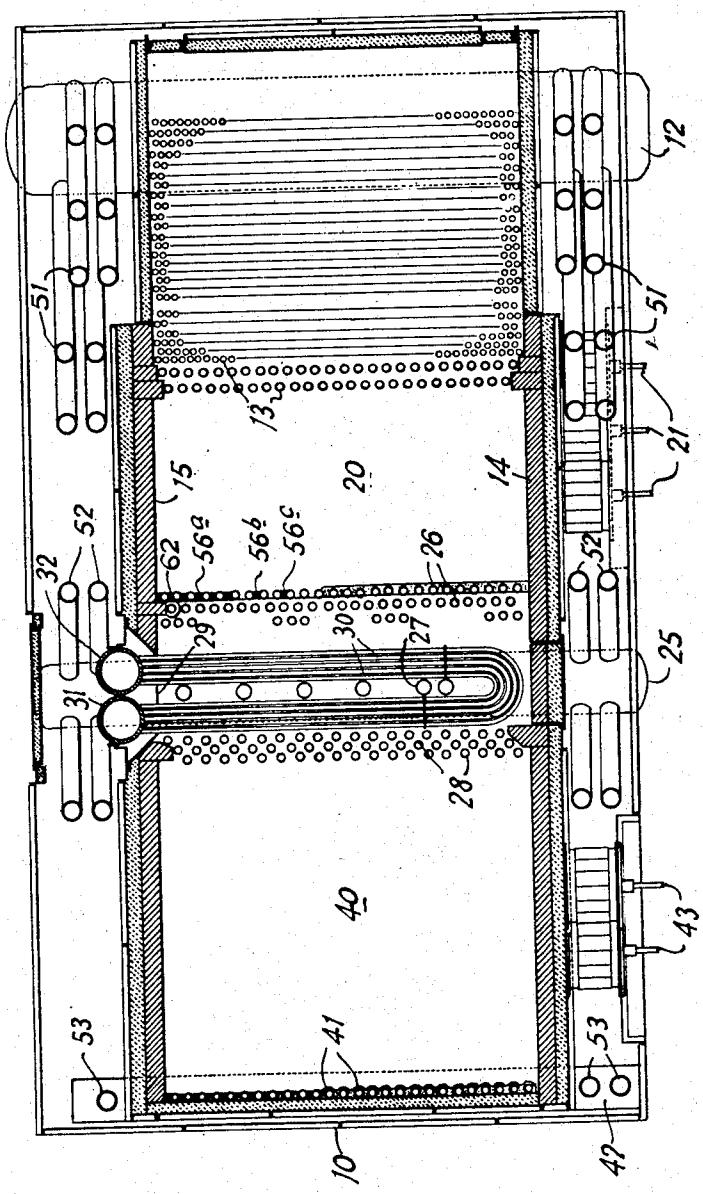
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Fig. 2



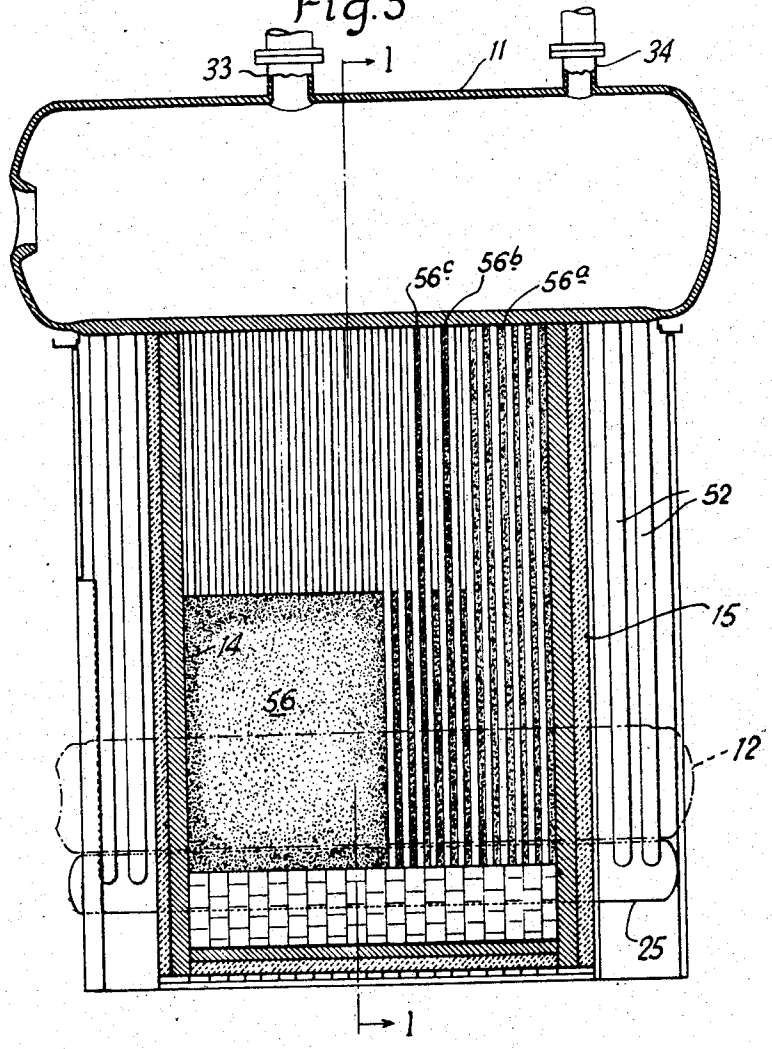
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Fig. 3



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2,429,976

VAPOR GENERATOR

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5 Claims. (Cl. 122—473)

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The present invention relates to the construction and operation of vapor generating units, and more particularly, to water tube steam boilers particularly designed for and especially useful in marine installations and including independently fired main and auxiliary furnace chambers having a common heating gas outlet at the opposite side of a main bank of steam generating tubes, and a group of steam superheating tubes located wholly or partly between the main and auxiliary furnace chambers and separated from the main furnace chamber by one or more rows of steam generating tubes and/or a partition extending upwardly for a portion of the height of the superheating surface, to shield the same from flame radiation from the main furnace chamber. With this construction and arrangement of the parts, in normal operation the main or "saturated" furnace is fired at a predetermined rate depending upon the desired rate of steam generation, while the auxiliary or "superheater" furnace is fired at a predetermined rate depending upon the rate of steam generation and the desired final steam temperature.

During starting-up periods and periods when only saturated or substantially saturated final steam temperatures are desired, the main furnace burners alone are operated and little or no steam may flow through the superheater. The protection of the superheater during such operating periods is particularly important to avoid excessive superheater tube metal temperatures and consequently damaging or leakage of the superheater tubes.

The general object of this invention is the provision of a steam boiler construction of the character described with improved provisions for protecting the superheater tubes from overheating, particularly when the main furnace alone is fired, without materially affecting the other operating results when both the main and auxiliary furnaces are in operation.

The various features of novelty which characterize my invention are pointed out with particularity 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 a preferred embodiment of my invention.

Of the drawings:

Fig. 1 is a partly diagrammatic elevation taken on the line 1—1 of Fig. 3 of a steam generating

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unit constructed in accordance with my invention;

Fig. 2 is an enlarged plan section taken on the line 2—2 of Fig. 1;

Fig. 3 is an enlarged vertical section taken on the line 3—3 of Fig. 1; and

Fig. 4 is an enlarged plan section taken on the line 4—4 of Fig. 1.

In the drawings, I have illustrated the invention as incorporated in a steam generating unit of the type shown in U. S. Patent No. 2,332,534, and comprising a setting 10 of rectangular horizontal cross-section, a steam and water drum 11, and a laterally offset lower water drum 12 connected to the drum 11 by an inclined bank of steam generating tubes 13. The tube bank 13 extends the full length of the setting between the refractory front wall 14 and rear wall 15 thereof. A heating gas outlet flue 18 containing an economizer 19 is arranged at the outer side of the tube bank. The main or saturated furnace chamber 20 is located at the inner side of the tube bank 13 and fired by a group of fluid fuel burners 21 mounted in burner ports 22 in the front wall 14.

A second water drum or header 25 is located directly below the steam drum 11 and connected thereto by transversely spaced groups of vertically extending steam generating tubes 26, 27 and 28. The front tubes 27 serve as supports for nested rows of horizontally arranged U-shaped superheater tubes 30 having their ends extending through a metal protecting plate 29 and connected to external vertical inlet and outlet headers 31 and 32 respectively. The header 31 is connected to a main steam outlet 33 on the drum 11. A separate outlet 34 for withdrawing saturated steam from the unit is also provided on the drum 11. The water tubes 26 and 28 are arranged in staggered rows at opposite sides of the superheater and extending the full length of the setting.

The auxiliary or superheater furnace chamber 40 is located at the outer side of the tube rows 28 and fired by a group of fluid fuel burners 43 mounted in burner ports 44 in the front wall 14. The outer side wall of the furnace chamber 40 has a row of water tubes 41 extending from a bottom header 42 to the steam drum 11. Downcomer tubes 51, 52 and 53 connect the water space of the drum 11 to the drums 12 and 25, and header 42 respectively. Short curved tube baffles 55 on the innermost row of tubes 28 close the spaces between the upper and lower ends of the superheater tube bank and the adjacent drums

and direct the flow of heating gases from the auxiliary furnace across the superheater tubes.

While the staggered rows of tubes **26** provide a tubular screen between the main furnace **20** and the superheater tubes **30**, absorbing much of the heat radiation from that furnace chamber while permitting heating gas flow through the tube rows from the auxiliary furnace **40**, additional protection is necessary to prevent the superheater tubes from being overheated, particularly when the main furnace alone is fired and saturated steam is withdrawn from the drum **11**. In such installations it is customary to use high grade heat resistant alloy steel tubes for the superheater elements in view of the high temperatures to which such tubes are exposed in normal operation. As shown in said U. S. Patent 2,232,534, a partition or baffle **56** extends upwardly from the drum or header **25**, being formed by metallic studs **57** welded along the length of the innermost row **26a** of the tubes **26** and a suitable refractory material, such as plastic chrome ore, closing the intertube portions of the tubes. Stud plates **58** are welded along the outer sides of the tubes **26a** to aid in retaining the refractory material in position. The partition **56** has the studs and refractory material covering the inner face of the tubes throughout the forward portion of its length, while the remaining portion has studs and refractory material in the intertube spaces only, as shown in Fig. 3, thus providing a refractory-faced construction in the forward portion of the partition and alternately tube surface and refractory in the rear portion.

Heretofore, the partition has been constructed to terminate throughout its length short of the upper drum **11** at approximately the level of the center line of the uppermost burner **21**, leaving a passage thereabove across which unstudded portions of the partition tubes **26a** extended and through which the heating gases from the auxiliary furnace **40** flowed across the upper part of the main furnace **20** and tube bank **13** to the heating gas outlet **18**. The space between the water tubes **26** and superheater tubes **30** forms a flow equalization space which aids in maintaining a substantially uniform heating gas flow from the auxiliary furnace chamber **40** over the length and height of the superheater tube bank.

It has been found that when the fuel burners **21** in the main furnace **20** alone are operated and saturated steam withdrawn through the auxiliary steam outlet **34**, the superheater tube metal temperatures, particularly in the superheater tube portions above the level of the partition **56** and adjacent the superheater header protection plate **29** in the rear wall **15**, tend to rise above a safe operating temperature, even when the superheater elements are made of high grade heat resistant alloy metal. It is believed that this overheating of the superheater elements is due to a high temperature gas flow from the rear portion of the main furnace **20** across the water tubes **26** and **28** and superheater tubes **30** into the auxiliary furnace **40**, probably due to a mushrooming effect induced by the impingement of products of combustion from the fuel burners **21** on the opposite portion of the rear wall **15**. These gases tend to return to the furnace chamber **20** across the forward portion of the water tubes **28** and **26** and superheater tubes **30**, forming in effect a "doughnut circuit" of the heating gases.

In accordance with my invention, the described undesirable heating gas flow can be reduced to an extent affording safe superheater tube metal operating temperatures throughout the operating range of the unit without materially affecting the other operating results. The provisions for this purpose include the extension of predetermined rear portions of the partition **56** upwardly towards the steam and water drum **11**. As shown in Figs. 2–4, the stud, stud plate and refractory construction on the six rearmost tubes **26a** is continued upwardly to the lower side of the drum **11** to form an upward imperforate partition extension **56a**. Similar upward partition extensions **56b** and **56c** are formed between the seventh and eighth and between the ninth and tenth tubes **26a** respectively. With this construction unobstructed gas flow passages will remain between the upper portions of the tubes **26a** from the front wall **14** for a major portion of the length of the partition **56** and similar gas flow passages will be present between the sixth and seventh and between the eighth and ninth tubes **26a** from the rear wall **15**. The resultant partition construction provides successive increases in the amount of shielding surface for the superheater tubes towards the rear of the main furnace chamber. The exact amount of partition area employed will vary with the main furnace chamber dimensions, the location and maximum rate of operation of the fuel burners **21**, and designed operating conditions, but in all cases the maximum height over which the partition extends will be at or adjacent to the rear wall **15**.

It is necessary to proportion the stud and stud plate lengths along the rear side of the tube **26a** nearest the rear wall **15** to provide a clearance space **60** between the rear end of both the partition **56** and extension **56a** and the rear wall **15**, permitting relative expansion of these parts. The setting of the unit tends to bulge outwardly when the boiler is in operation, thus increasing the size of the clearance space **60**. To minimize heating gas flow through the clearance space **60**, the rear wall **15** is provided with a refractory corbel **62** along the outer side of the partition and its extension **56a** for the entire height of those parts.

Boilers of the construction described having the described partition construction have been tested with the main or saturated furnace burners alone in operation at capacities up to 68,000 lb. of saturated steam per hour without any portion of the superheater elements exceeding a safe tube metal operating temperature. The vertical extension of the rear portion of the partition acts to minimize mushrooming of the heating gases impinging on the rear wall into the space occupied by the superheater while not materially affecting the other operating results when either the main or auxiliary furnace burners are operated separately or together. The effect of this partition extension construction on the final superheated steam temperature, air pressure requirements and combustion efficiency under such conditions was found to be negligible.

I claim:

1. A steam generator comprising a setting having front and rear walls, an upper steam and water drum, a lower water drum, a bank of steam generating tubes connecting said upper and lower drums, a second lower water drum, a group of spaced water tubes connecting the upper drum to said second water drum, a main furnace chamber between said tube bank and said tube group, fuel burning means arranged to effect a flow of heating gases rearwardly of said main furnace chamber, a group of spaced super-

heater tubes adjacent the outer side of said tube group, an auxiliary furnace chamber laterally adjoining the outer side of said superheater tubes, means for firing said auxiliary furnace chamber, said superheater tubes being arranged directly in the path of the heating gases leaving said auxiliary furnace chamber so as to receive heat mainly by convection, a single heating gas outlet flue at the outer side of said tube bank and arranged to receive all of the heating gases flowing from both of said furnace chambers, said flue being so located that the heating gases from said auxiliary furnace chamber flow across said superheater tubes and substantially all the tubes of said group, through said main furnace chamber and across said tube bank before entering said flue, and means forming a partition at the superheater side of said main furnace chamber extending substantially the full length thereof, the portion of said partition adjacent said rear wall extending upwardly from approximately said second water drum to said upper drum and arranged to obstruct heating gas flow from said main furnace chamber across adjacent tubes of said tube group and towards said superheater tubes.

2. A steam generator comprising a setting having front and rear walls, an upper steam and water drum, a lower water drum, a bank of steam generating tubes connecting said upper and lower drums, a second lower water drum, a group of spaced water tubes connecting the upper drum to said second water drum, a main furnace chamber between said tube bank and said tube group, fuel burning means arranged to effect a flow of heating gases rearwardly of said main furnace chamber, a group of spaced superheater tubes adjacent the outer side of said tube group, an auxiliary furnace chamber laterally adjoining the outer side of said superheater tubes, means for firing said auxiliary furnace chamber, said superheater tubes being arranged directly in the path of the heating gases leaving said auxiliary furnace chamber so as to receive heat mainly by convection, a single heating gas outlet flue at the outer side of said tube bank and arranged to receive all of the heating gases flowing from both of said furnace chambers, said flue being so located that the heating gases from said auxiliary furnace chamber flow across said superheater tubes and substantially all of the tubes of said tube group, through said main furnace chamber and across said tube bank before entering said flue, and means forming a partition at the superheater side of and extending longitudinally substantially the full length of said main furnace chamber, the forward section of said partition being arranged to direct the heating gas flow from said auxiliary furnace chamber across the upper part of said main furnace chamber, and the rear portion of said partition adjacent said rear wall being extended upwardly a substantial distance towards said upper drum and arranged to obstruct any heating gas flow from said main furnace chamber across the adjacent tubes of said tube group and towards said superheater tubes.

3. A steam generator comprising a setting having front and rear walls, an upper steam and water drum, a lower water drum, a bank of steam generating tubes connecting said upper and lower drums, a second lower water drum, a group of spaced water tubes connecting the upper drum to said second water drum, a main furnace chamber between said tube bank and said tube group,

fluid fuel burners in said front wall arranged to effect a flow of heating gases rearwardly of said main furnace chamber, a group of spaced superheater tubes adjacent the outer side of said tube group, an auxiliary furnace chamber laterally adjoining the outer side of said superheater tubes, means for independently firing said auxiliary furnace chamber, said superheater tubes being arranged directly in the path of the heating gases leaving said auxiliary furnace chamber so as to receive heat mainly by convection, a single heating gas outlet flue at the outer side of said tube bank and arranged to receive all of the heating gases flowing from both of said furnace chambers, said flue being so located that the heating gases from said auxiliary furnace chamber flow across said superheater tubes and substantially all of the tubes of said tube group, through said main furnace chamber and across said tube bank before entering said flue, and means including tubes of said tube group forming a fluid cooled partition at the superheater side of and extending longitudinally substantially the full length of said main furnace chamber, the forward section of said partition extending upwardly for part of the length of the tubes in said tube group and arranged to direct the heating gas flow from said auxiliary furnace chamber across the upper part of said main furnace chamber and to shield said superheater tubes from flame radiation from said main furnace chamber, and the portion of said partition adjacent said rear wall being extended upwardly to said upper drum and arranged to obstruct heating gas flow from said main furnace chamber across the adjacent tubes of said tube group and towards said superheater tubes.

4. A steam generator comprising a setting having front and rear walls, an upper steam and water drum, a lower water drum, a bank of steam generating tubes connecting said upper and lower drums, a second lower water drum, a group of spaced water tubes connecting the upper drum to said second water drum, a main furnace chamber between said tube bank and said tube group, fuel burning means arranged to effect a flow of heating gases rearwardly of said main furnace chamber, a group of spaced superheater tubes adjacent the outer side of said tube group, an auxiliary furnace chamber laterally adjoining the outer side of said superheater tubes, means for firing said auxiliary furnace chamber, said superheater tubes being arranged directly in the path of the heating gases leaving said auxiliary furnace chamber so as to receive heat mainly by convection, a single heating gas outlet flue at the outer side of said tube bank and arranged to receive all of the heating gases flowing from both of said furnace chambers, said flue being so located that the heating gases from said auxiliary furnace chamber flow across said superheater tubes and substantially all of the tubes of said tube group, through said main furnace chamber and across said tube bank before entering said flue, and means forming a partition at the superheater side of said main furnace chamber extending substantially the full length thereof, the portion of said partition adjacent said rear wall extending upwardly from approximately said second water drum to said upper drum, and a corbel on said rear wall at the outer side of said partition and cooperating therewith to obstruct heating gas flow from said main furnace chamber across the adjacent tubes of

said tube group and towards said superheater tubes.

5. A steam generator comprising a setting having front and rear walls, an upper steam and water drum, a lower water drum, a bank of steam generating tubes connecting said upper and lower drums, a second lower water drum, a group of spaced water tubes connecting the upper drum to said second water drum, a main furnace chamber between said tube bank and said tube group, fuel burning means arranged to effect a flow of heating gases rearwardly of said main furnace chamber, a group of spaced superheater tubes adjacent the outer side of said tube group, an auxiliary furnace chamber laterally adjoining the outer side of said superheater tubes, means for firing said auxiliary furnace chamber, said superheater tube group extending substantially the entire length of said auxiliary furnace chamber and arranged directly in the path of the heating gases therefrom so as to receive heat mainly by convection, a single heating gas outlet flue at the outer side of said tube bank and arranged to receive all of the heating gases flowing from both of said furnace chambers, said flue being so located that the heating gases from said auxiliary furnace chamber flow across said superheater tubes and substantially all the tubes of said tube group, through said main furnace chamber and across said tube bank before entering said flue, and means forming a gas flow restricting baffle at the superheater side of said main furnace chamber extending substantially the full length thereof and successively increasing in cross-sectional area towards said rear wall and arranged to obstruct heating gas flow from said main furnace chamber across the adjacent tubes of said tube group and towards said superheater tubes.

ERVIN G. BAILEY.

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