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STEAM BOILER

Filed Aug. 13, 1937

2 Sheets-Sheet 1

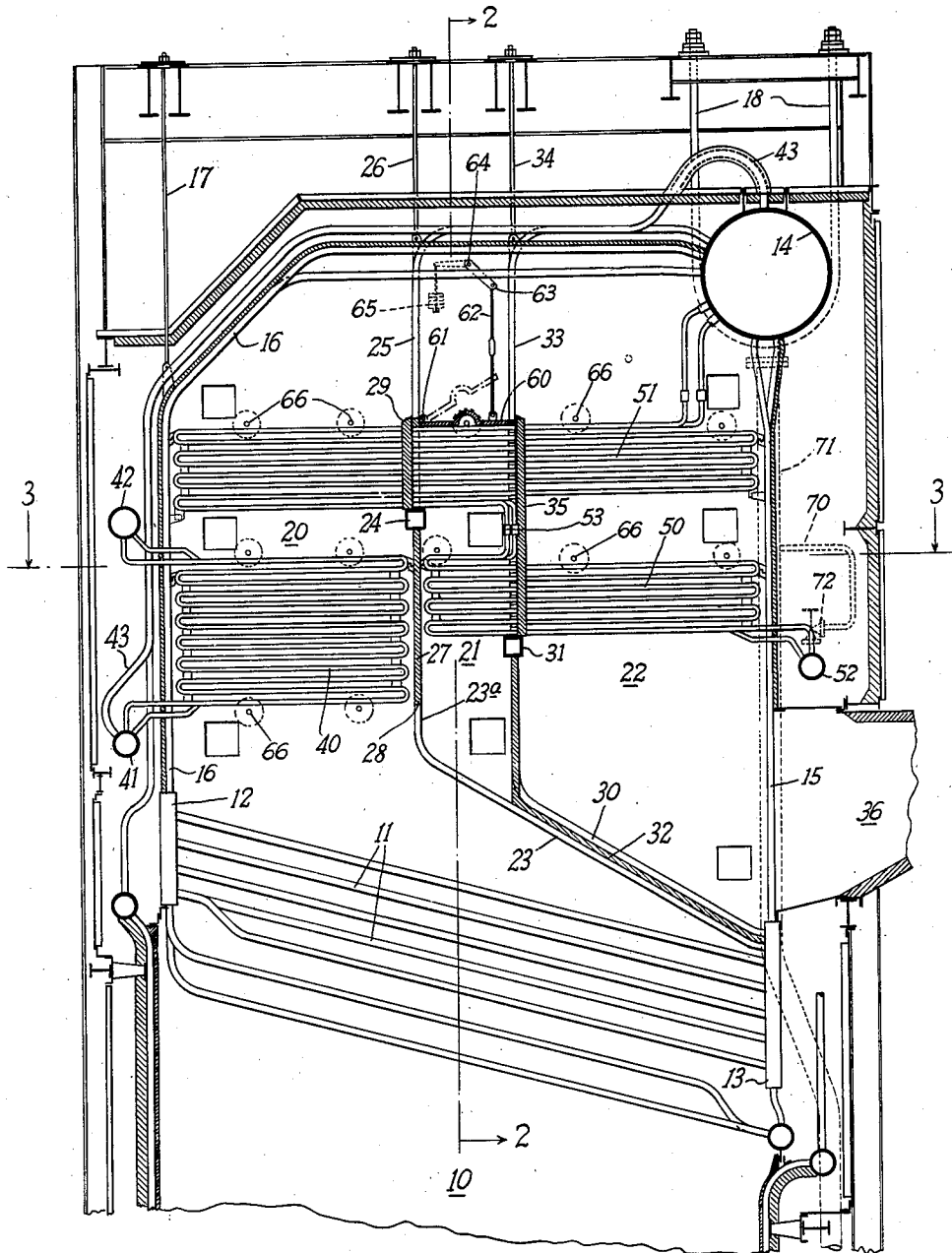


Fig. 1

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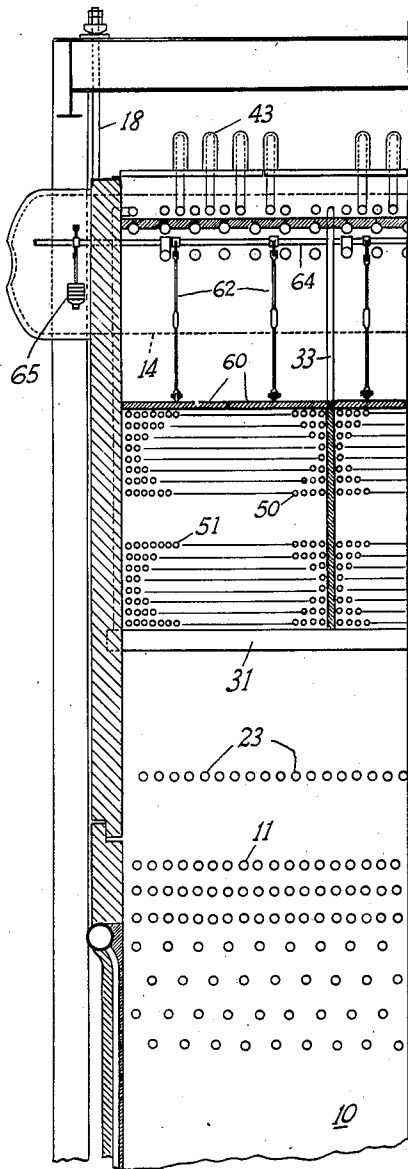


Fig. 2

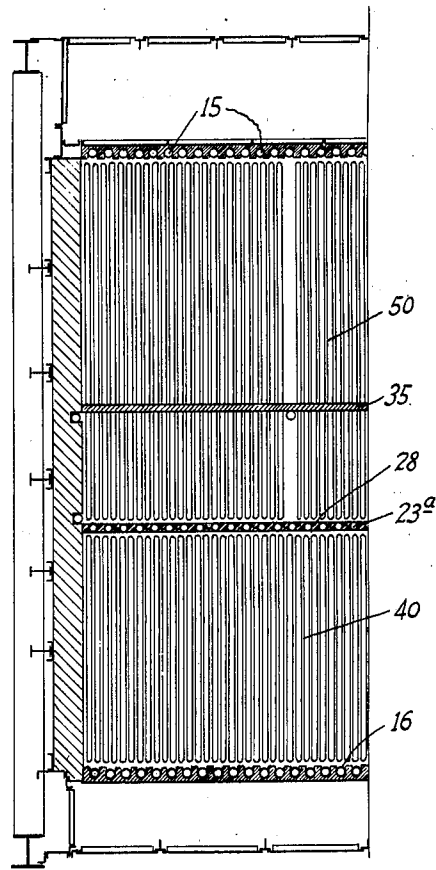


Fig. 3

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STEAM BOILER

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10 Claims. (Cl. 122—480)

The present invention relates to the construction and operation of steam generators including convection heated steam heating surface and provisions for regulably by-passing heating gases around the steam heating surface when desired.

It is well known that modern high pressure steam generators deliver steam at the superheater outlet with temperatures as high as 900° to 950° F. Under these conditions it is important that the steam temperature entering the turbine be maintained at a designed value. Higher steam temperatures may exceed the safe limit for the turbine or the superheater tubes, while lower steam temperatures will result in reduced plant efficiency and probably excessively increased moisture in the final or low pressure turbine stages. All operating conditions cannot be maintained constant such as dirtiness of tubes and quality of fuel, for example, and some of these will affect the superheated steam temperature. Variation in the latter conditions can be compensated by superheat control. Constant superheated steam temperature from maximum boiler output to two-thirds or one-half maximum is now desired in representative economic practice.

It is also well known that there is considerable danger of the superheater surface becoming overheated when there is little or no steam flow therethrough, such as during starting-up periods. This danger can be minimized by by-passing a sufficient portion of the furnace gases around the superheater.

The general object of our invention is the provision of a steam generator of the character described with a simple and effective superheater construction which is further characterized by the arrangement of auxiliary heating surface of high heat absorbing capacity in the gas by-pass around the superheater for protecting the by-pass control provisions and maintaining the thermal efficiency of the unit when the by-pass is in use. A further and more specific object is an improved construction and arrangement of a steam heating surface by-pass in a steam generator of the Babcock & Wilcox high head type which is characterized by its simplicity and low cost of construction, effectiveness, low draft loss, and low maintenance.

The various features of novelty which characterize the 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 we have illustrated and described a preferred embodiment of our invention.

Of the drawings:

Fig. 1 is a partly diagrammatic sectional elevation of the upper portion of a steam generator unit constructed in accordance with our invention;

Fig. 2 is a vertical section taken on the line 2—2 of Fig. 1; and

Fig. 3 is a plan section taken on the line 3—3 of Fig. 1.

In the drawings is illustrated a steam generator of the Babcock & Wilcox high head type with the convection heated surface arranged across the outlet of a water cooled furnace 10, the wall cooling provisions of which form part of the steam generating surface and are connected for circulation in a well known manner. The pressure parts include a horizontally inclined bank of steam generating tubes 11 extending across the top of the furnace and having their upper and lower ends connected to uptake headers 12 and downtake headers 13 respectively. The lower tube rows of the bank and the tubes therein are widely spaced to form a slag screen. A steam and water drum 14 extends transversely of and a substantial distance above the downtake headers 13, being connected to the latter by vertical downcomer tubes 15 and to the uptake headers 12 by riser tubes 16 extending vertically along the front side of the setting, and then horizontally along the top of the setting to the drum 14. The pressure parts described are top supported from the surrounding steel work by means of hanger rods 17 connected to the upper end of the vertical portions of the riser tubes 16 and U-shaped hangers 18 extending around the drum 14.

The setting space defined by the tube bank, risers and downcomers with the high drum, is of substantial volume and advantageously employed for the location of the auxiliary economizer and superheater surface of the unit. In accordance with our invention this space is divided into a pair of laterally adjoining upflow gas passes 20 and 21 and a laterally adjoining downflow gas pass 22. The provisions for this purpose comprise a row of tubes 23 extending inwardly and upwardly from the upper portion of the row of downtake headers 13 and having vertical upper portions 23^a connected to a transverse box header 24. The tubes 23 and header 24 are connected into the boiler circulation system and are adequately supported from the ex-

ternal steel work by means of tubes 25 extending vertically from the header 24 and then transversely into the drum 14 and hanger rods 26 connecting the vertical portions of the tubes 25 to the top steel work. The tube portions 23^a are partly studded along their intertube sides to support refractory material 27 for closing the intertube spaces and forming a baffle or partition 28 between the upflow passes 20 and 21. A refractory baffle 29 is mounted on the header 24 and forms a continuation of the baffle 28.

A transverse series of tubes 30 extend inwardly and upwardly from the down take headers 13 with inclined and vertical portions arranged parallel to the corresponding portions of the tubes 23, with the upper ends of the tubes 30 connected to a transverse header 31. A refractory baffle 32 extends from the downtake header 13 between the inclined portions of the tubes 23 and 30, and then vertically along the vertical portions of the tubes 30 to the header 31. A series of supporting tubes 33 extend vertically up from the header 31 and then horizontally to the drum 14, the tubes 33 being supported by hanger rods 34 in the same manner as the tubes 16 and 25. A refractory baffle 35 extends vertically along the tubes 33 from the header 31 to a level corresponding to the upper end of the baffle 29. The baffles 28, 29, 32 and 35 extend the full width of the setting and divide the space between the circulator rows into the wide and narrow upflow passes 20 and 21 respectively and the downflow pass 22, the remaining sides of the passes being defined by the setting.

With the described baffle arrangement heating gases will flow vertically across the full length of the steam generating tube bank 11 and on leaving the tubes 11 are caused to converge by the inclined portion of the baffle 32 towards the front side of the unit. The converging gases will be divided by the partition 28 between the wide upflow pass 20 and the narrow pass 21, and flow vertically therethrough. The gas streams combine on leaving the upper ends of the passes 20 and 21 and flow downwardly through the downflow pass 22 to a gas outlet 36 opening through the rear side of the setting immediately above the downtake headers 13.

In accordance with our invention the steam heating surface of the unit is confined to the lower portion of the upflow pass 20, and as shown, consists of a steam superheater having a series of multiple loop flat tube coils 40 arranged side-by-side transversely of the gas pass and having their lower and upper ends connected to inlet and outlet headers 41 and 42 respectively, the inlet header 41 being connected to the upper part of the drum 14 by tubes 43. With this arrangement the superheater 40 will extend entirely across the upflow gas pass 20. The opposite looped ends of each tube coil have a supporting connection with the circulator tubes 16 and baffle tube portions 23 permitting expansion and contraction of the superheater tubes in operation.

The water heating or economizer surface of the unit is preferably divided into two sections, a lower inlet section 50 and an upper outlet section 51 serially connected thereto, and each comprising a series of multiple loop tube coils constructed and arranged similar to the superheater tubes 40. The lower ends of the lower section economizer tubes are connected to a feed water inlet header 52, while the upper ends of the upper section economizer tubes are connected di-

rectly to the drum 14. The lower economizer section 50 is horizontally arranged with its tube legs extending through the baffle 35 and its looped end portions adjacent the tubes 23 and 15 respectively. The lower economizer section is movably supported at one end from the circulator tubes 15 and at an intermediate point adjacent the opposite end on the header 31. The upper ends of the tubes 50 are serially connected to corresponding tubes in the upper economizer section 51 by connectors 53 located within the gas pass 21 adjacent the baffle 35. The tube coils of the upper economizer section extend not only through the baffle 35, but also through the baffle 29, with the opposite looped ends of these tubes adjacent to and movably supported from the circulator tubes 15 and 16. The header 24 serves as an intermediate support for the upper economizer section. Movement of the economizer tube banks relative to one another and to their supporting means is thus permitted.

With this arrangement the heating gases flowing upwardly through the wide gas pass 20 will first contact with the superheater tubes 40 and then with the front end portion of the economizer tube bank 51, while the gases flowing through the narrow upflow pass 21 contact successively with the front end portion of the lower economizer section and an intermediate portion of the upper economizer section. The heating gases leaving the upflow passes 20 and 21 combine and flow downwardly through the gas pass 22 over the rear portions of the upper and lower economizer sections in succession. The fluid flow through the tubes of the auxiliary heating surface in the upflow gas passes will thus be parallel to the heating gas flow, while in the downflow pass 22 the internal fluid flow will be counter to the heating gas flow.

The narrow upflow pass 21 serves as the superheater by-pass through which a regulable portion of the heating gases may be caused to flow. The by-pass control provisions consist of a series of metallic dampers 60 extending across the upper end of the gas pass 21 and in their closed position resting on the uppermost row of economizer tubes 51. The dampers 60 are hinged at 61 adjacent the baffle 29. The damper operating mechanism comprises an adjustable turnbuckle rod 62 connecting the upper side of the damper to a lever arm 63 carried by a control shaft 64 extending transversely of the setting immediately below the roof thereof. A counterweight 65 is arranged on each end of the shaft 64, and the dampers 60 may be manually or automatically controlled to vary the portion of the heating gases passing through the by-pass 21. Soot blower elements 66 are arranged at various points adjacent the auxiliary surface.

The described location of the dampers relative to the economizer surface is especially advantageous in that a sufficient amount of relatively cold economizer surface is arranged below the dampers to reduce the temperature of the by-passed gases to a safe temperature before they contact with the dampers.

During starting-up periods, the economizer tubes 50 and 51, being below the normal water level, will be filled with water, although the feed water supply connection to the header 52 is not normally open. The water in the economizer tubes will be rapidly heated to the saturation temperature. To avoid the economizer tubes, and especially the tube portions within the by-pass 21, becoming steam-bound, a circulation

through the economizer tubes is established by providing recirculation tubes 70 connected to external downcomers 71, leading from the drum 14 to the furnace water walls, and the economizer inlet header 52, the connection being controlled by a manually operable valve 72, although automatic control means responsive to the fluid condition in the economizer tubes may be employed where desirable. During this period, there will be little, if any, steam flow through the superheater tubes. The by-pass dampers 60 are therefore moved to their wide open position to provide a maximum flow of heating gases through the by-pass 21 and this reduces the gas flowing over the superheater tubes to a minimum. When the unit is ready to deliver steam the economizer recirculator tube valves 72 are closed and the connection between the economizer inlet header 62 and the feed pump opened, to provide a forced flow through the economizer tubes to the drum 14. The dampers 60 are gradually moved toward their closed positions to increase the proportion of the gases passing over the superheater and subsequently regulated as to position to obtain the desired superheat temperatures.

The by-pass construction described requires a relatively low initial investment and few changes in structural design from the standard boilers of this type. The amount of economizer surface within the by-pass, while sufficient to reduce the temperature of the heating gases to a safe temperature before contacting with the control dampers, renders only a small portion of the economizer surface thermally ineffective when the by-pass is entirely closed, and thereby minimizes the loss in thermal efficiency during such periods. However, the by-pass will normally be partly open so that the economizer surface swept by the gases flowing through it, will be effective.

While in accordance with the provisions of the statutes we have illustrated and described herein the best form of the invention known to us, 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 the claims, and that certain features of our invention may sometimes be used to advantage without a corresponding use of other features.

We claim:

1. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged above said tube bank, uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, baffle means arranged to divide the space defined by said tube bank, circulator tubes and drum into a plurality of gas passes including a pair of adjoining upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, steam heating surface arranged in and confined to one of said upflow passes, economizer surface arranged in the other of said upflow passes, and damper means for said other upflow pass arranged for varying the distribution of the heating gases between said upflow passes.

2. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged above said tube bank, uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, baffle means arranged to divide the space defined by said tube bank, circulator tubes and drum into a plurality of gas passes including a

pair of adjoining upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, steam heating surface arranged in one of said upflow passes, economizer surface arranged in the other of said upflow passes and said downflow pass, and a flow control damper for said last mentioned upflow pass arranged immediately above said economizer surface.

3. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged a substantial distance above said tube bank, uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, baffle means arranged to divide the space defined by said tube bank, circulator tubes and drum into a pair of adjoining wide and narrow upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, steam heating surface arranged in said wide upflow pass, economizer surface arranged in said narrow upflow pass and said downflow pass, and a flow control damper for said narrow upflow pass arranged immediately above said economizer surface.

4. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged above said tube bank, uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, baffle means arranged to divide the space defined by said tube bank, circulator tubes and drum into a plurality of gas passes including a pair of upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, a bank of steam heating tubes extending across and confined to one of said upflow passes, a sectional economizer comprising an upper tube bank extending across said downflow pass and said upflow passes and a lower tube bank extending across only the other of said upflow passes and said downflow pass, and a flow control damper for said last mentioned upflow pass arranged above said economizer upper tube bank.

5. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged a substantial distance above said tube bank, uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, baffle means arranged to divide the space defined by said tube bank, circulator tubes and drum into a pair of wide and narrow upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, a bank of steam heating tubes extending across and confined to said wide upflow pass, a sectional economizer comprising an upper tube bank extending across said downflow pass and said upflow passes and a lower tube bank extending across only said narrow upflow pass and said downflow pass, and a flow control damper for said narrow upflow pass arranged above said economizer upper tube bank.

6. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged a substantial distance above said tube bank, uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, longitudinally spaced rows of vertically disposed fluid conduit elements having their lower ends communicating with said down flow circulator tubes and their upper ends with said drum, baffle means asso-

ciated with said elements and dividing the space defined by said tube bank, circulator tubes and drum into a plurality of gas passes including a pair of wide and narrow upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, a bank of steam heating tubes extending across and confined to said wide upflow pass, a bank of economizer tubes extending across said narrow upflow pass and said downflow pass, and a flow control damper for said narrow upflow pass arranged above said economizer tube bank.

7. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged a substantial distance above said tube bank, uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, longitudinally spaced rows of vertically disposed fluid conduit elements having their lower ends communicating with said downflow circulator tubes and their upper ends with said drum, baffle means associated with said elements and dividing the space defined by said tube bank, circulator tubes and drum into a plurality of gas passes including a pair of wide and narrow upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, a bank of steam heating tubes extending across and confined to said wide upflow pass, a bank of economizer tubes extending across said narrow upflow pass and said downflow pass, a transverse header incorporated in one of said rows of elements and forming a support for said economizer tube bank, and a flow control damper for said narrow upflow pass arranged above said economizer tube bank.

8. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged a substantial distance above said tube bank, uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, longitudinally spaced rows of vertically disposed fluid conduit elements having their lower ends communicating with said downflow circulator tubes and their upper ends with said drum, baffle means associated with said elements and dividing the space defined by said tube bank, circulator tubes and drum into a plurality of gas passes including a pair of wide and narrow upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, a bank of steam heating tubes extending across and confined to said wide upflow pass, a sectional economizer comprising an upper tube bank extending across said downflow pass and said upflow passes and a lower tube bank extending across only said narrow upflow pass and said downflow pass, and a flow control damper for

said narrow upflow pass arranged above said economizer upper tube bank.

9. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged a substantial distance above said tube bank, uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, longitudinally spaced rows of vertically disposed fluid conduit elements having their lower ends communicating with said downflow circulator tubes and their upper ends with said drum, means for supporting said elements independently of said drum, baffle means associated with said elements and dividing the space defined by said tube bank, circulator tubes and drum into a pair of wide and narrow upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, a bank of steam heating tubes extending across and confined to said wide upflow pass, a sectional economizer comprising an upper tube bank extending across said downflow pass and said upflow passes and a lower tube bank extending across only said narrow upflow pass and said downflow pass, a header incorporated in one of said rows of elements and forming a support for said economizer upper tube bank, a second header incorporated in the other row of elements and forming a support for said economizer lower tube bank, and a flow control damper for said narrow upflow pass arranged above said economizer upper tube bank.

10. A steam boiler comprising a bank of inclined steam generating tubes, a transverse steam and water drum arranged above said tube bank, groups of uptake and downtake circulator tubes connecting the opposite ends of said tube bank to said drum, baffle means arranged to divide the space defined by said tube bank, circulator tube groups and drum into a pair of parallel upflow passes and a laterally adjoining downflow pass serially connected to said upflow passes at their upper ends, a sectional economizer comprising an upper tube bank extending across said downflow pass and both of said upflow passes and connected at its upper end to said drum, and a lower economizer tube bank serially connected to said upper tube bank and extending across only one of said upflow passes and said downflow pass, steam heating surface confined to the other of said upflow passes, damper means for said one upflow pass, means for supplying feed water to the lower end of said lower economizer tube bank, and recirculator connections connecting the water space of said drum to the lower end of said lower economizer tube bank.

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