

Sept. 7, 1937.

J. E. BLACK ET AL

2,092,299

STEAM BOILER

Original Filed Dec. 8, 1932

Fig. 3.

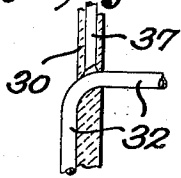
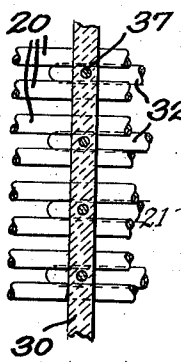
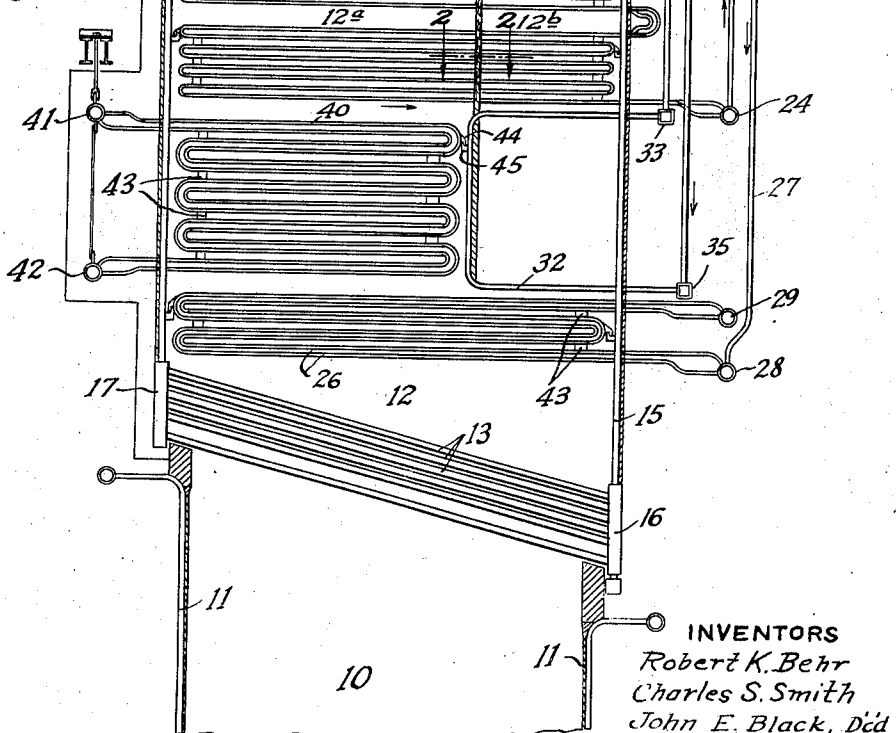


Fig. 2.



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2,092,299

STEAM BOILER

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N. J., and Charles S. Smith, Westfield, N. J.,
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Application December 8, 1932, Serial No. 646,256
Renewed June 18, 1935

20 Claims. (Cl. 122—299)

The present invention relates in general to the construction and operation of water tube steam boilers incorporating auxiliary fluid heating surface in a space above a main bank of steam generating tubes and below the gas outlet from the boiler.

More specifically the present invention relates to the construction and operation of high pressure steam boilers incorporating a convection heated steam superheater and a reheater for superheating steam between stages of an associated multi-stage prime mover, such as a steam turbine. In steam boilers of the character described, the temperature to which the steam is reheated will ordinarily vary directly with the rating at which the boiler is operated, due to the varying amount of heating gases to which the reheater is subjected. The temperature of the steam entering the reheater will also vary due to variations in the pressure drop through the first stage of the turbine. Efficient turbine operation demands substantially constant steam temperature conditions at the stage of return of the reheated steam. It is therefore highly desirable that the final reheat temperature of the steam be kept substantially constant with varying boiler loads.

The general object of our invention is the provision of a steam boiler of the general character described with an improved construction and arrangement of the auxiliary fluid heating surface therein.

A more specific object of our invention is the improved construction of a high pressure water tube steam boiler of the high drum type incorporating both a steam superheater and steam reheater and provisions for controlling the final reheat temperature.

The various features of novelty which characterize our 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 drawing and descriptive matter in which we have illustrated and described a preferred embodiment of our invention.

Of the drawing:

Fig. 1 is a somewhat diagrammatic sectional elevation of a superheater boiler incorporating our invention;

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

Fig. 3 is a sectional elevation of a tube supporting connection.

The steam boiler illustrated in the drawing comprises a combustion chamber 10 formed by fluid cooled walls 11 and above which is arranged a vertical heating gas pass 12. A bank of steam generating tubes 13 extends across the lowermost portion of the gas pass 12. The tubes 13 are connected to a horizontal steam and water drum 14 arranged transversely of the boiler at an elevation considerably above the uppermost point of steam generation in the tube bank by vertically arranged downtake circulators 15 and uptake circulators 18 connected respectively to the downtake headers 16 and uptake headers 17. The tubes 13 form a natural circulation steam generating bank through which a rapid circulation of the fluid is effected under the high head due to the location of the drum 14. The vertical portions of the circulators 15 and 18 define opposite sides of the heating gas pass 12. The gas pass is provided at its upper rear side with a gas outlet 19.

In the upper portion of the gas pass 12, but below the gas outlet 19, is arranged an economizer 20, consisting of superposed banks of return bend tubes supported by the uptake and downtake circulators and detachably connected by return bends located externally of the gas pass for a series flow of fluid therebetween. The supporting provisions for the economizer consist of lugs 21 carried by the circulators and slidably engaging lugs 22 mounted on return bend portions of the economizer tubes. Feed water is delivered to the economizer inlet header 23, and flows downwardly through the economizer sections to the economizer outlet header 24 which is connected to the steam and water drum 14 by tubes 25. In the space between the tube bank 13 and the lowermost economizer section is arranged a superheater 26 consisting of a plurality of rows of return bend tubes extending horizontally across the gas pass 12 and supported from the uptake and downtake circulators in a manner similar to the economizer sections. The superheater receives a supply of steam from the drum 14 through tubes 27 connected to the superheater inlet header 28. The superheated steam passes out through the superheater outlet header 29 to an associated steam turbine.

The portion of the heating gas pass 12 above the superheater is divided into side-by-side channels 12^a and 12^b by a vertical baffle 30 extending upwardly to a level above the bottom of the gas outlet 19 and then horizontally into the outlet passage dividing the latter into horizontal channels 19^a and 19^b. Dampers 31^a and 31^b are ar-

ranged in the rear portions of the channels 19^a and 19^b respectively, and can be manipulated to control the relative amounts of heating gases flowing through the main gas pass channels 12^a and 12^b. The described location for the control dampers does not require the use of special designs or materials which would otherwise be necessary in case the control dampers were located in a higher temperature zone.

- 10 The baffle 30 is advantageously supported at its lower end by a row of U-shaped steam generating tubes 32 having their lower legs extending across the lower end of the channel 12^b and upwardly along the uptake side of the baffle 30, which is secured thereto in any suitable manner. The upper legs of the tubes 32 also extend across the channel 12^b below the lowermost economizer section and pass between the circulators 15 into a header 33. The tubes 32 are preferably connected into the circulating system of the boiler by downcomers 34 connected to a header 35 at the lower end of the tubes 32 and uptake circulators 36 connecting the header 33 to the steam space of the drum 14. The load on the tubes 32 is carried by rods 37 embedded in the baffle 30 and extending downwardly from a top support 38 between the economizer tubes and connected to the upper bend of the tubes 32 in any suitable manner, as by welding. The use of supporting rods for this purpose does not affect the economizer tube spacing, nor will their exposed portions be subjected to unduly high gas temperatures.

- In the portion of the channel 12^a between the superheater and lowermost economizer section is arranged a steam reheater 40 consisting of a double row of nested return bend tubes extending across the channel 12^a and having their ends connected to externally supported inlet and outlet headers 41 and 42 respectively. The reheater tubes, like the economizer and superheater tubes are formed in a unitary truss-like structure by plates 43 welded to vertically adjacent legs thereof. The inner end of the reheater is supported from the rods 37 by lugs 44 on the inner looped portions of the reheater tubes engaging lugs 45 on the vertical portions of the tubes 32 in a manner similar to the arrangement of the lugs 21 and 22 previously described.

- 50 With the boiler constructed as described, feed water is supplied under pressure to the economizer 20 and delivered to the drum 14, from which it is circulated through the steam generating elements 13 and 32 of the boiler. The steam generated passes from the drum 14 to the superheater, where the steam is superheated before being delivered to the point of use, such as a multi-stage steam turbine. Modern power plant practice prescribes reheating of the steam between certain turbine stages, and this is done in the present construction by passing the steam from a high pressure stage to the reheater inlet header 41.

- In constructions where the boiler reheater is subjected to the flow of all of the heating gases at different boiler ratings, the reheating effect will vary directly with the amount of heating gases to which it is subjected. Even with a constant reheating effect, the final temperature to which the steam is reheated will vary with changes in the pressure of the steam at the point of return to the reheater. In the present construction, a substantially constant final reheat temperature is obtained by regulating the amount of heating gases to which the reheater is sub-

jected by varying the relative positions of the dampers 31^a and 31^b to thereby regulate the proportions of the heating gases passed through the channels 12^a and 12^b respectively. The reheater surface is preferably proportioned to attain the desired amount of reheat at the full output rating of the boiler with both control dampers wide open. At lower ratings of the boiler the damper 31^b will be moved towards its closed position to increase the proportion of heating gases passing through the gas channel 12^a as required to maintain the desired final reheat temperature. If the final reheat temperature should tend to exceed the desired value, the degree of opening of the damper 31^a is decreased and that of the damper 31^b increased to provide the greater proportion of the flow through the channel 12^b. A substantially constant final reheat temperature can thus be maintained by proper positioning of the dampers 31^a and 31^b.

The described construction is particularly advantageous in that the control of the final reheat temperature has little or no effect on the heat transfer in the economizer and super-heater, as any change in the proportions of the heating gas passing through the channels 12^a and 12^b will merely vary the mass flow of the heating gases passing over the portions of the economizer and superheater surface located in said channels, but will not change the total amount of heating gases supplied to those parts.

While in accordance with the provisions of the statutes we have illustrated and described herein the best forms of our invention now 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 our 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 water tube boiler comprising a combustion chamber, a bank of steam generating tubes receiving heating gases from said combustion chamber, a steam and water drum positioned above said tube bank, circulators connecting opposite ends of said tube bank to said drum and defining a vertical heating gas pass above said tube bank, a waste gas outlet, a baffle extending transversely of said tube bank and dividing said gas pass into a plurality of vertical channels connected to said gas outlet, a bank of auxiliary fluid heating tubes extending through said baffle and across said channels, a second bank of auxiliary fluid heating tubes located in only one of said channels, and means for varying the relative amounts of heating gases flowing through said channels.

2. A water tube boiler comprising a combustion chamber, a bank of steam generating tubes receiving heating gases from said combustion chamber, a steam and water drum positioned a substantial distance above said tube bank, circulators connecting opposite ends of said tube bank to said drum and defining a vertical heating gas pass above said tube bank, a waste gas outlet adjacent said drum, a vertical baffle dividing said gas pass into a plurality of channels from beyond said tube bank to said gas outlet, a fluid cooled support for said baffle, a group of steam heating tubes located in one of said channels, means for partly supporting said steam heating tubes from said fluid cooled support, and dampers at the upper ends of said channels for varying the relative

amounts of heating gases flowing through said channels.

3. A water tube boiler comprising a combustion chamber, a bank of steam generating tubes receiving heating gases from said combustion chamber, a steam and water drum positioned a substantial distance above said tube bank, circulators connecting opposite ends of said tube bank to said drum and defining a vertical heating gas pass above said tube bank, a waste gas outlet adjacent said drum, a superheater extending across said gas pass above said tube bank, a vertical baffle dividing said gas pass into a plurality of channels from beyond said superheater to said gas outlet, a row of steam generating tubes extending along said baffle and providing a fluid cooled support therefor, a steam reheater located in one of said channels, and means for varying the relative amounts of heating gases flowing through said channels.

4. A water tube boiler comprising a combustion chamber, a bank of steam generating tubes receiving heating gases from said combustion chamber, a steam and water drum positioned a substantial distance above said tube bank, circulators connecting opposite ends of said tube bank to said drum and defining a vertical heating gas pass above said tube bank, a waste gas outlet adjacent said drum, a superheater extending across said gas pass above said tube bank, a vertical baffle dividing said gas pass into a plurality of channels from beyond said superheater to said gas outlet, a row of steam generating tubes extending along said baffle and providing a fluid cooled support therefor, a steam reheater located in one of said channels and including a row of return bend tubes, means for supporting return bend portions of said return bend tubes from said row of steam generating tubes, and means for varying the relative amounts of heating gases flowing through said channels.

5. A steam generator comprising a setting, a bank of inclined steam generating tubes within said setting, a steam and water drum extending transversely of and above said tube bank, circulators connecting the opposite ends of said tube bank to said drum, a heating gas outlet at one side of said setting above one end of said tube bank, a row of tubes extending inwardly at the downtake end of said tube bank and upwardly intermediate the length of and above said tube bank and having their upper ends connected to said drum, suspension means external to said drum for supporting said row of tubes, a vertically extending baffle supported on the vertically extending portion of said row of tubes and having a lateral extension to said heating gas outlet and arranged to separate a pair of parallel flow gas passes extending above said tube bank and laterally to said heating gas outlet, a bank of fluid heating tubes extending across one of said gas passes, a second bank of fluid heating tubes in the other gas pass, and damper means in said heating gas outlet for varying the relative amounts of heating gases flowing through said gas passes.

6. A steam generator comprising a setting, a bank of inclined steam generating tubes within said setting, a steam and water drum extending transversely of and above said tube bank, circulators connecting the opposite ends of said tube bank to said drum, a row of tubes extending upwardly intermediate the length of and above said tube bank, suspension means external to said drum for supporting said row of tubes, a vertically extending baffle supported on the vertically ex-

tending portion of said row of tubes with its lower end terminating above said tube bank and arranged to separate a pair of parallel flow gas passes extending above said tube bank, a bank of steam heating tubes extending across one of said gas passes, a bank of economizer tubes in the other gas pass, and damper means for varying the relative amounts of heating gases flowing through said gas passes.

7. A steam generator comprising a setting, a bank of inclined steam generating tubes within said setting, a steam and water drum above said tube bank, circulators connecting the opposite ends of said tube bank to said drum, a row of tubes extending upwardly intermediate the length of and above said tube bank, suspension means external to said drum for supporting said row of tubes, a vertically extending baffle supported on the vertically extending portions of said row of tubes and arranged to separate a pair of parallel flow gas passes above said tube bank, a bank of fluid heating tubes extending across only one of said gas passes, damper means for varying the relative amounts of heating gases flowing through said gas passes, and means for supporting one end of said fluid heating tube bank from said row of tubes and suspension means.

8. A steam generator comprising a setting, a bank of inclined steam generating tubes within said setting, a steam and water drum above said tube bank, circulators connecting the opposite ends of said tube bank to said drum, a row of tubes extending inwardly at the downtake end of said tube bank and upwardly intermediate the length of and above said tube bank and having their upper ends connected to said drum, suspension means external to said drum for supporting said row of tubes, a vertically extending baffle supported on the vertically extending portions of said row of tubes and arranged to separate a pair of parallel flow gas passes above said tube bank, a bank of fluid heating tubes extending across one of said gas passes, damper means for controlling the proportion of the heating gases flowing through the other gas pass, and means for supporting one end of said fluid heating tube bank from said row of tubes and suspension means.

9. A steam generator comprising a setting, a bank of steam generating tubes within said setting, a steam and water drum above said tube bank, circulators connecting the opposite ends of said tube bank to said drum, a row of tubes extending upwardly intermediate the length of and above said tube bank, suspension means for supporting said row of tubes, a vertically extending baffle supported on the vertically extending portions of said row of tubes and arranged to separate a pair of parallel flow gas passes above said tube bank, a bank of fluid heating tubes extending across one of said gas passes, means for supporting one end of said fluid heating tube bank from said row of tubes and suspension means, a second bank of fluid heating tubes in the other gas pass, and damper means for varying the relative amounts of heating gases flowing through said gas passes.

10. A steam generator comprising a setting, a bank of inclined steam generating tubes within said setting, a steam and water drum extending transversely of said tube bank and directly above the downtake end thereof, circulators connecting the opposite ends of said tube bank to said drum, a row of tubes extending inwardly at the downtake end of said tube bank and upwardly intermediate the length of and above said tube bank

and having their upper ends connected to said drum, suspension means external to said drum for supporting said row of tubes, a vertically extending baffle supported on the vertically extending portions of said row of tubes and arranged to separate a pair of parallel flow gas passes above said tube bank, a bank of steam heating tubes extending across one of said gas passes, means for supporting one end of said steam heating tube bank from said row of tubes and suspension means, a bank of economizer tubes in the other gas pass, and damper means in the upper ends of said gas passes for varying the relative amounts of heating gases flowing through said gas passes.

11. A steam generator comprising a setting, a bank of inclined steam generating tubes within said setting, a steam and water drum extending transversely of and above said tube bank, circulators connecting the opposite ends of said tube bank to said drum, a heating gas outlet at one side of said setting above one end of said tube bank, a row of tubes extending upwardly intermediate the length of and above said tube bank, suspension means external to said drum for supporting said row of tubes, a vertically extending baffle supported on the vertically extending portions of said row of tubes and arranged to separate a pair of parallel flow gas passes extending above said tube bank and laterally to said heating gas outlet, a bank of steam heating tubes extending across one of said gas passes, means for supporting one end of said steam heating tube bank from said row of tubes and suspension means, a bank of economizer tubes in the other gas pass, and damper means in said heating gas outlet for varying the relative amounts of heating gases flowing through said gas passes.

12. A steam generator comprising a setting, a group of steam generating tubes arranged across said setting, a steam and water drum extending transversely of and above said steam generating tubes, rows of circulator tubes arranged at opposite sides of said setting and connecting the opposite ends of said steam generating tube group to said drum, a heating gas outlet in the upper part of said setting, means forming a vertical baffle extending transversely of said steam generating tube group and dividing the space between said rows of circulator tubes into a pair of parallel gas passes having an upflow of heating gases therein to said gas outlet, a group of steam heating tubes positioned in only one of said gas passes, a group of economizer tubes positioned in the other gas pass, and damper means for varying the relative amounts of heating gases flowing through said gas passes.

13. A steam generator comprising a setting, a group of steam generating tubes arranged across said setting, a steam and water drum arranged above said steam generating tubes, rows of circulator tubes vertically disposed along opposite sides of said setting and connecting the opposite ends of said steam generating tube group to said drum, means including a row of fluid heating tubes having portions extending vertically within said setting and arranged to form a baffle extending transversely of said steam generating tube group and separating a pair of parallel gas passes of different cross-sectional flow areas within the space between said rows of circulator tubes and having an upflow of heating gases therein, a group of return bend steam heating tubes extending across only the gas pass of greater flow area, means for supporting one end of said

steam heating tubes from said baffle-forming tubes, and damper means for varying the amount of heating gases flowing through the gas pass of lesser flow area.

14. A steam generator comprising a setting, a bank of inclined steam generating tubes arranged across said setting, a steam and water drum arranged transversely of and above said steam generating tubes, rows of uptake and down-take circulator tubes vertically disposed along opposite sides of said setting and connecting the corresponding ends of said steam generating tubes to said drum, a row of fluid heating tubes having portions extending inwardly adjacent the down-take end of said tube bank and vertically intermediate the length of said tube bank and having their upper ends connected to said drum, a vertically extending baffle supported on the vertically extending portions of said row of tubes and arranged to extend transversely of said tube bank and separate a pair of parallel gas passes of different cross-sectional flow areas within the space between said rows of circulator tubes, and having an upflow of heating gases therein, the gas pass of greater flow area being arranged directly above the uptake end of said tube bank, a group of steam heating tubes extending across only the gas pass of greater flow area, and damper means for controlling the amount of heating gases flowing through the gas pass of lesser flow area.

15. A steam generator comprising a setting, a group of steam generating tubes arranged across said setting, a steam and water drum extending transversely of and above said steam generating tubes, circulator tubes vertically disposed along opposite sides of said setting and connecting the opposite ends of said steam generating tube group to said drum, means including a row of fluid heating tubes having portions extending vertically within said setting and arranged to form a baffle extending transversely of said steam generating tube group and separating a pair of adjacent gas passes within said setting, suspension means for supporting the vertically extending portions of said baffle-forming tubes, a group of return bend fluid heating tubes extending across only one of said gas passes, means for supporting one end of said return bend tubes from said baffle-forming tubes and suspension means, a second group of return bend fluid heating tubes extending through said baffle and across said gas passes, damper means for varying the relative amounts of heating gases flowing through said gas passes, and means for supporting the opposite ends of said second group of return bend tubes from adjacent circulator tubes.

16. A steam generator comprising a setting, a group of steam generating tubes arranged across said setting, a steam and water drum extending transversely of and above said steam generating tubes, circulator tubes connecting the opposite ends of said steam generating tube group to said drum, means forming a baffle extending transversely of said steam generating tube group and separating a pair of adjacent gas passes within said setting above said steam generating tube group, a group of steam heating tubes located in only one of said gas passes, a group of economizer tubes located in both of said gas passes and above said steam heating tubes, and damper means located in the path of gas flow beyond said economizer tubes for varying the relative amounts of heating gases flowing through said gas passes.

17. A water tube boiler comprising a combustion chamber, a bank of steam generating tubes

located above said combustion chamber, a steam and water drum positioned above said tube bank, circulators connecting opposite ends of said tube bank to said drum and defining a vertical heating gas pass above said tube bank, a waste gas outlet adjacent said drum, a baffle extending transversely of said tube bank and dividing said gas pass into a pair of channels from beyond said tube bank to said gas outlet, a group of steam heating tubes located in one of said channels, a bank of auxiliary fluid heating tubes above said steam heating tubes and extending through said baffle into both of said channels, and means at the upper ends of said channels for varying the relative amounts of heating gases flowing through said channels.

18. A steam generator comprising a setting, a group of steam generating tubes arranged across said setting, a steam and water drum above said steam generating tube group, groups of circulator tubes extending along opposite sides of said setting and connecting the opposite ends of said steam generating tube group to said drum, a vertically extending baffle arranged to divide a portion of said setting above said steam generating tube group and between said circulator tube groups into a pair of laterally adjacent vertically extending gas passes, a group of steam heating tubes extending across only one of said gas passes, a group of multi-looped return bend economizer tubes in the other gas pass, means for supporting at least one end of said group of economizer tubes from adjacent circulator tubes, and damper means for varying the relative amounts of heating gases flowing through said gas passes.

19. A steam generator comprising a setting, groups of circulator tubes extending along opposite sides of said setting, a vertically extending

baffle arranged to divide a portion of said setting between said circulator tube groups into a pair of laterally adjacent vertically extending gas passes having an upflow of heating gases therein, a group of return bend steam heating tubes extending across only one of said gas passes, a group of multi-looped return bend economizer tubes in the other gas pass, means for supporting the opposite ends of said group of economizer tubes from adjacent circulator tubes, and damper means for varying the relative amounts of heating gases flowing through said gas passes.

20. A steam generator comprising a setting, a group of steam generating tubes arranged across said setting, a steam and water drum a substantial distance above said steam generating tube group, groups of circulator tubes extending along opposite sides of said setting and connecting the opposite ends of said steam generating tube group to said drum, a vertically extending baffle arranged to divide a portion of said setting above said steam generating tube group and between said circulator tube groups into a pair of laterally adjacent vertically extending gas passes having an upflow of heating gases therein, a group of return bend steam heating tubes extending across only one of said gas passes, a group of multi-looped return bend economizer tubes in the other gas pass, means for supporting the opposite ends of said group of economizer tubes from adjacent circulator tubes, and damper means in the path of gas flow beyond said economizer tubes for varying the relative amounts of heating gases flowing through said gas passes.

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