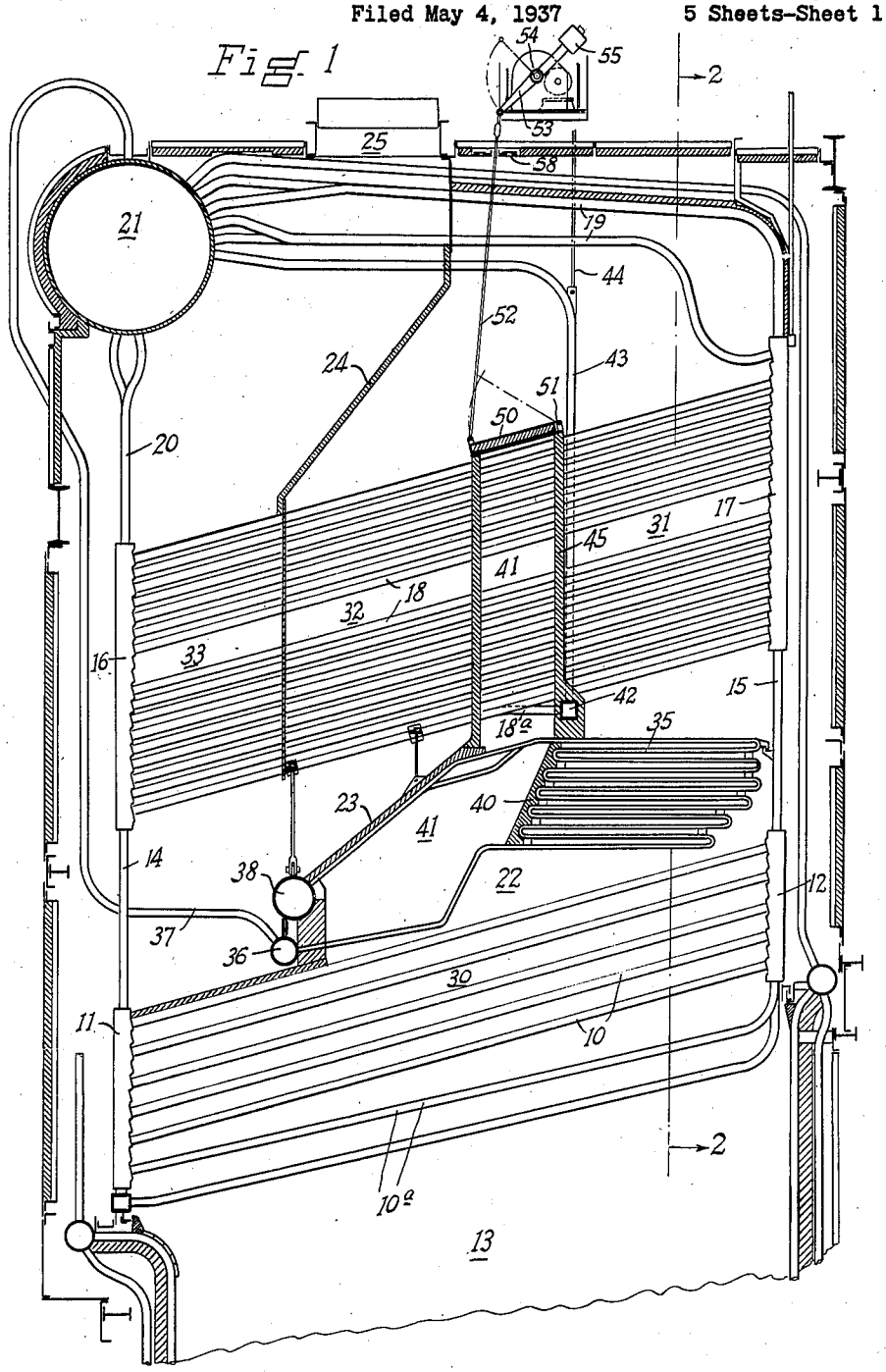
Aug. 20, 1940. G. D. EBBETS ET AL 2,212,115

STEAM BOILER

Filed May 4, 1937 5 Sheets-Sheet 1

Fig. 1



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STEAM BOILER

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Fig. 2

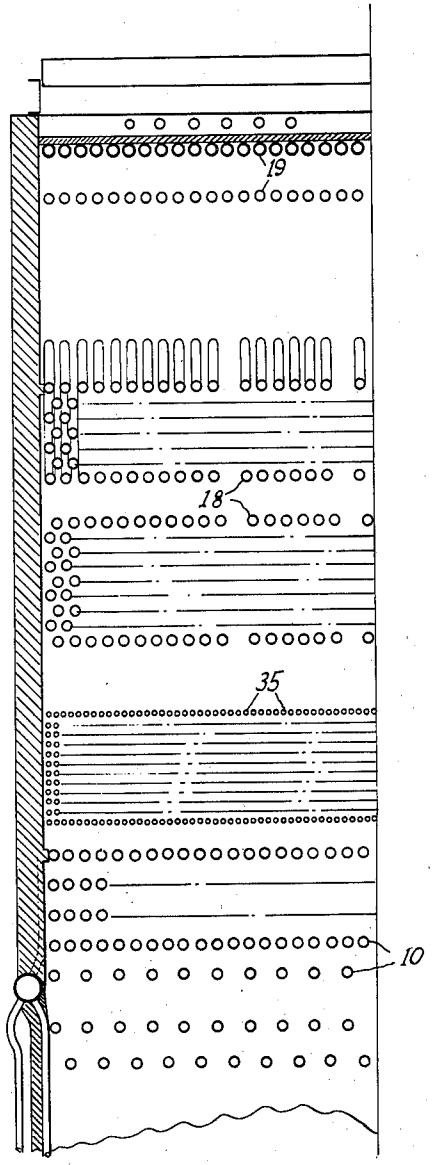
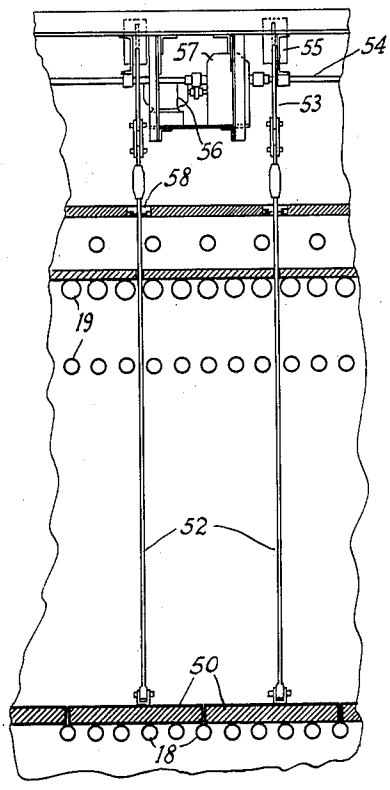


Fig. 3



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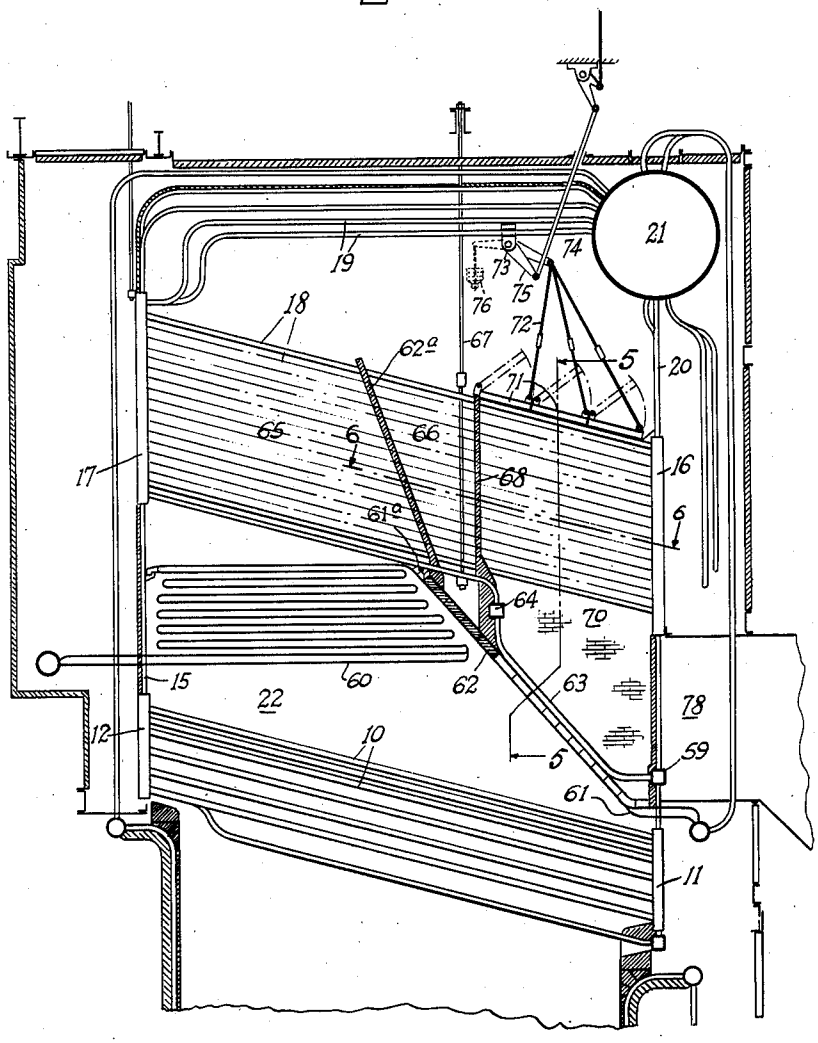
BY Basil R. Manning ATTORNEY.

Aug. 20, 1940. G. D. EBBETS ET AL 2,212,115

STEAM BOILER

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Fig. 4



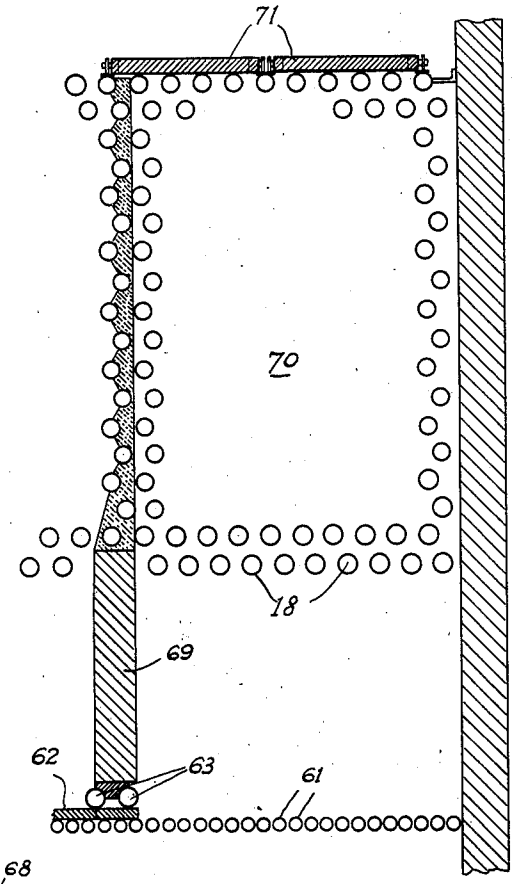
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STEAM BOILER

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Fig. 5



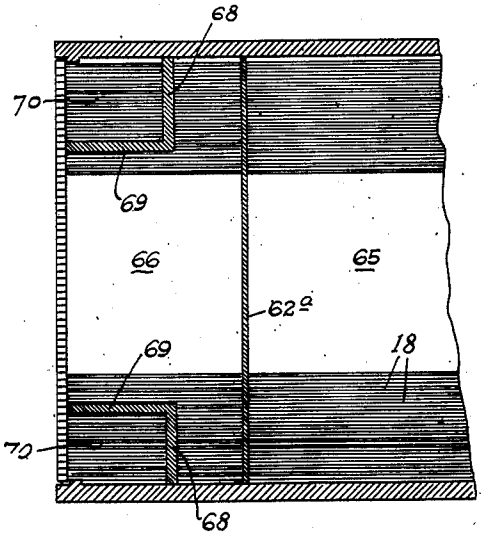


Fig. 6

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STEAM BOILER

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Fig. 7

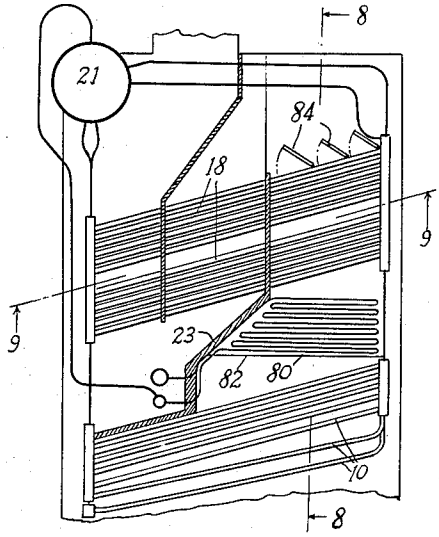
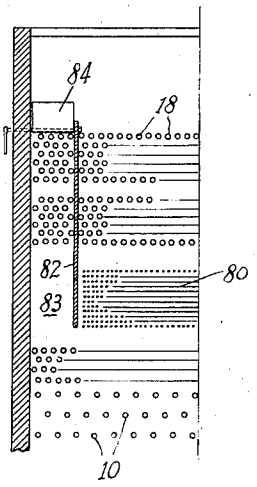


Fig. 8



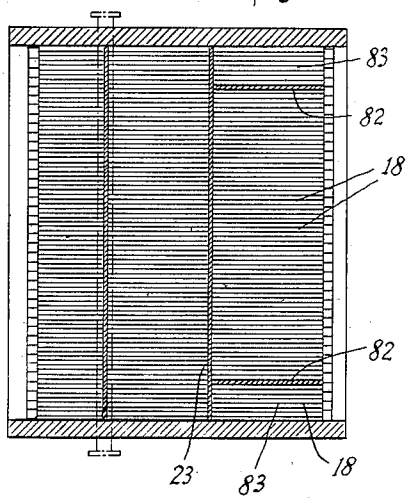


Fig. 9

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UNITED STATES PATENT OFFICE

2,212,115

STEAM BOILER

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Application May 4, 1937, Serial No. 140,724

10 Claims. (Cl. 122—480)

This invention relates to the construction and operation of steam generating units, and particularly to water tube steam boilers of the Babcock & Wilcox type incorporating convection heated steam superheating surface.

In a modern steam generating unit in which the steam is superheated by convection heat transfer, the superheating surface must be located in a zone in which the heating gas temperatures are sufficiently high to secure the relatively high final superheat temperature desired, but yet not sufficient to cause overheating of the superheater tubes when the steam flow through the superheater tubes is within the probable operating range. The liability of such superheater tubes to be overheated is considerably increased when the steam flow through the superheater is low, as during starting-up periods before the initiation of an appreciable steam flow.

A further problem in steam boilers of the character described is the difficulty of maintaining a uniform final superheat temperature over the boiler operating range. It is known that such convection heated superheaters normally have a final superheat temperature curve with a rising characteristic with increase in boiler load when the amount of gases passing over the superheater surface is directly proportional to the products of combustion.

For the foregoing reasons, it is recognized as highly desirable to control the amount of heating gases passing in heat transfer relation with the convection heated superheating surface. One type of such control which has been heretofore proposed consists in by-passing a variable portion of the heating gases around the superheater. Such by-pass arrangements are objectionable as they usually require a special and expensive construction of the boiler, are not readily adapted for incorporation in existing boilers of standard design, involve the loss of a considerable portion of boiler generating surface having a high rate of heat transfer when the by-pass is closed and inoperative, or require the use of control dampers in locations where the heating gas temperature conditions are excessive and cause overheating of the dampers or render them ineffective, to the extent that the overall operating efficiency of the unit may be reduced.

The general object of this invention is the provision of an improved superheater by-pass arrangement and construction for steam boilers of the Babcock & Wilcox type. A further and more specific object is the provision of a superheater by-pass arrangement and construction in a double deck steam boiler of the type described which is characterized by its relatively simple and low cost of construction, effectiveness over a wide range of boiler operating conditions, adaptability for incorporation in existing steam boilers of standard design, relatively small amount of low rate heat absorbing surface rendered ineffective when the by-pass is closed, improved location and construction of the by-pass control dampers, and effective control of the amount of heating gases contacting wtih the superheater tubes over a wide range of operating conditions.

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 preferred embodiments of the invention.

Of the drawings:

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

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

Fig. 3 is a vertical section showing the damper operating mechanism;

Fig. 4 is a view similar to Fig. 1 of a modified construction;

Fig. 5 is a partial vertical section taken on the line 5—5 of Fig. 4;

Fig. 6 is a horizontal section taken on the line 6—6 of Fig. 4;

Fig. 7 is a somewhat diagrammatic sectional elevation of another modification;

Fig. 8 is a vertical half section taken on the line 8—8 of Fig. 7; and

Fig. 9 is a horizontal section taken on the line 9—9 of Fig. 7.

The steam boiler illustrated in Figs. 1 to 3 of the drawings is of the Babcock & Wilcox double deck cross drum type comprising a lower bank of horizontally inclined steam generating tubes 10 extending between vertically arranged sectional downtake and uptake headers 11 and 12 respectively, and arranged across the upper end of a water cooled furnace 13 adapted for the burning of fluid fuel, such as pulverized coal, oil or gas, in suspension at high rates of heat release. As shown in Figs. 1 and 2, the lowermost rows 10a of the tube bank are arranged to form a boiler slag screen, while the remaining rows are arranged in vertical alignment. The headers

11 and 12 are connected by nipples 14 and 15 respectively, to corresponding downtake and uptake headers 16 and 17 respectively, between which extend staggered rows of horizontally inclined steam generating tubes 18 forming an upper steam generating bank. The headers 17 and 16 are connected by horizontal circulator tubes 19 and downtake tubes 20 respectively, to a steam and water drum 21 extending transversely of and above the tube banks. A space 22 is thus provided between and extending the full length of the tube banks.

The steam generating surface described is provided with a baffle system which in conjunction with the boiler setting defines a single upflow heating gas pass across the lower tube bank, and a plurality of serially connected upflow and downflow gas passes across the upper tube bank. As shown, a refractory baffle 23 extends from the downtake headers 11 along the uppermost row of tubes 10 of the lower bank for a portion of their length, thence vertically and forwardly through the interdeck space 22 and vertically across the tubes 18 of the upper bank. A second transverse baffle 24 extends downwardly and rearwardly from one side of a gas outlet 25 to the upper bank and vertically across the same. The described baffle system is well known in steam boilers of this type, and in conjunction with the boiler setting provides a single upflow heating gas pass 30 across the lower tube bank 12 which communicates through a tapering portion of the interdeck space 22 with an upflow gas pass 31 at the uptake end of the upper tube bank. The gas pass 31 is serially connected over the upper end of the baffle 23 with a downflow gas pass 32 which in turn communicates below the lower end of the baffle 24 with a second upflow gas pass 33 leading to the gas outlet 25. The heating gases leaving through the gas outlet 25 may be passed through a feed water economizer, or air heater, or both, before reaching the stack.

In steam boilers of the character described the interdeck space 22 is ordinarily utilized for a convection heated steam superheater, as the gas temperatures in this section are sufficient to effect the high final superheat temperatures now required in high capacity units, while the superheating tubes are protected from excessive heating gas temperatures in normal operation by the lower tube bank. As shown, the uptake end of the interdeck space 22 is occupied by a bank of multiple looped horizontally extending superheating tubes 35 arranged in flat side-by-side unitary coils for the full width of the boiler. The lowermost tube leg of each coil is connected to a superheater inlet header 36 at the downtake side of the baffle 23, receiving steam from the drum 21 through tubes 37. The uppermost tube leg of each coil has a portion extending downwardly along and supporting an inclined portion of the baffle 23 with its lower end connected to a steam outlet header 38. The uptake end of each superheater tube coil has an expansible supporting connection with a corresponding nipple 15. With the described boiler construction the heating gases pass upwardly across the lower tube bank, thence upwardly across the superheater tubes 35, and successively through the heating gas passes 31, 32, and 33 to the gas outlet.

In accordance with the invention, a heating gas by-pass around the superheater is provided by terminating the downtake ends of the superheater tube loops forwardly of the baffle 23 and embedding the same in the refractory baffle 40 extending the full width of the interdeck space 22 and defining the uptake side of a relatively narrow by-pass 41 between the baffle 40 and the baffle 23. The baffle 40 and the downtake end of the superheater tubes are supported from an auxiliary header 42 extending transversely below the upper bank, and receiving a supply of water from certain tubes 18a in the lowermost row of the upper bank. The header 42 is connected by spaced supporting tubes 43 extending upwardly intermediate the tubes 18 to the drum 21. The tubes 43 are supported by vertical hanger rods 44 carried by the external steel work. A vertical baffle 45 extends across the upper tube bank alongside the tubes 43 from the header 42 to the uppermost row of the bank to define the uptake side of the by-pass 41 across the tube bank. With the by-pass 41 open a substantial portion of the heating gases leaving the lower tube bank would pass upwardly across the upper tube bank without contacting with the superheating tubes except for the relatively small portion thereof formed by the connections to the inlet and outlet headers. On reaching the top of the by-pass, the by-passed gases join the heating gas stream which has passed over the superheater tubes and the combined gas streams pass over the upper end of the baffle 23 and downwardly through the gas pass 32.

The heating gas flow through the by-pass is effectively controlled in the present construction by means of a row of dampers 50 extending across the upper end thereof. Each of the dampers 50 is formed by a shallow rectangular box of heat resistant alloy steel filled with heat insulating material. Each damper is pivotally supported as indicated at 51 on the upper end of the baffle 45, and when in its closed position extends along the uppermost row of tubes 18 with its downtake end resting on the upper end of the baffle 23. Each damper extends across a plurality of the tubes 18 in the uppermost row of the upper bank substantially in contact therewith, so that a substantial cooling effect is effected by these tubes on the damper when the damper is in its closed position. Even when the damper is in its fully open position, indicated by the broken lines in Fig. 1, the subjacent tubes 18 will exert a substantial cooling effect.

The damper operating mechanism illustrated comprises an adjustable link rod 52 pivotally connected to the downtake end of the damper and to a lever 53 carried by an operating shaft 54 and having an adjustable counterweight 55. The shaft 54 is a common operating shaft for a number of dampers and is actuated by a reversible electric motor 56 through a speed reducer 57. A sliding seal 58 is provided in the top of the boiler setting to permit vertical and lateral movements of each link 52.

In the modified steam boiler construction illustrated in Figs. 4 to 6 the interdeck superheater 60 extends horizontally in the interdeck space the full length of the upflow heating gas pass, with its downtake end supported from a downwardly and rearwardly inclined extension 61 of the uppermost superheater tube leg of each coil, which in turn is supported from the upper tube bank at 61a. The main boiler baffle 62 is formed by tile extending between the tube legs 61 and a row of water tubes 63 extending parallel to the tube legs 61, with their upper ends engaging a transverse header 64 to which spaced groups of tubes in the lowermost row of the upper bank are connected. The upper portion 62a

of the baffle 62 extending across the upper tube bank is inclined to provide tapering gas passes across the upper bank. The lower ends of the tubes 63 are connected to a header 59 incorporated in the downtake nipples. Hanger rods 67 provide a support for the tubes 63. The transverse baffle section 62a divides the space occupied by the upper tube bank into an upflow gas pass 65 and a downflow gas pass 66. The downtake corner portions of the downflow pass are occupied by the upflow superheater by-passes 70 hereinafter described.

The front wall of each superheater by-pass 70 is defined by a refractory baffle 68 which is supported on and extends upwardly from the tubes 63 at a point adjacent the lower end of the superheater. The portion of each baffle 68 extending across the upper tube bank is of poured refractory, and extends the full height of the upper tube bank. The inner side wall of each by-pass, as shown in Fig. 5, is defined by a fire-brick and plastic refractory wall 69 carried by the tubes 63 and extending throughout the space at the rear of and above the baffle 62 between the baffle 68 and the rear wall of the setting. As indicated in Fig. 5, the portion of the baffle 62 which would be below each by-pass 70 is omitted to permit an upflow of heating gases through the by-passes.

The control mechanism for regulating the heating gas flow through each by-pass consists of three pivoted dampers 71 similar to those shown in Figs. 1 to 3, movable between the full line closed positions and the broken line open positions indicated in Fig. 4. Each of the dampers is operated by an adjustable rod 72 of heat resistant alloy steel connected to a common operating shaft 73 by a lifting arm 74. The shaft 73 is oscillated by a bell crank lever 75 carrying a counterweight 76 and connected to a suitable external oscillating mechanism (not shown).

With the described construction the main path of heating gas flow from the furnace chamber will be upwardly across the lower tube bank, superheater, and the portion of the upper tube bank at the uptake side of the baffle 62a. The gases then turn over the upper end of the baffle 62a and pass downwardly through the portion of the downflow gas pass 66 between the by-passes 70 to a gas outlet 78. The arrangement of the by-passes and their control dampers in the downtake corners of the setting substantially reduces the heat transfer to the dampers when in their closed position. When the by-pass dampers are partly or fully open, a portion of the heating gases leaving the lower tube bank will by-pass the superheater and flow vertically past the sides of the baffle 62 into each by-pass. The gases flowing through the by-passes pass over the upper ends of the baffles 68 and 69 and join the gas stream flowing downwardly through the surrounding downflow gas pass 66 to the gas outlet 78.

In the modified construction diagrammatically illustrated in Figs. 7 to 9, the superheater tube coils 80 extend the full length of the space between the main boiler baffle 23 and the uptake nipples, but as shown in Fig. 8, terminate short of the side walls of the setting. A vertical baffle 82 extends along each side of the superheater between the tubes 18 of the upper bank to the uppermost tube row of the upper bank to define a vertically extending superheater by-pass 83 at the uptake side of the baffle 23 between one of the baffles 82 and the adjacent side wall of the setting. A row of externally operated control dampers 84 is located at the upper end of each by-pass along the top row of the upper bank. With the described construction the by-passed gases will flow upwardly at each side of the gas stream through the upflow pass at the uptake end, merging with that stream to flow through the subsequent downflow and upflow gas passes of the upper bank.

In all of the boiler constructions illustrated the superheater by-pass or by-passes are formed by vertical non-tortuous upflow gas passages. The pressure drop through these passages is consequently utilized for heat transfer purposes rather than in effecting changes in direction of the gas flow. The pressure drop through each by-pass will obviously be lower than through the gas pass containing the superheater, and consequently an effective control of the heating gas flow across the superheater can be maintained even at low boiler ratings. The only heat absorbing surface included in each by-pass is part of the upper bank of generating tubes which operate with a substantially lower rate of heat absorption than the surface in the lower bank, thus utilizing secondary heating surface of the boiler to secure adequate protection of the by-pass control dampers and reduce the gas temperature sufficient to maintain overall unit thermal efficiency. The construction and location of these dampers and their operating mechanism not only insures a long life in operation but also the absence of any warping of the dampers permits the control mechanism to be maintained fully effective. The tube and baffle support of the dampers in their closed position reduces the stresses on the damper operating mechanism. An effective control of the heating gas flow across the superheater is thus provided which can be employed to by-pass a major portion of the heating gases around the superheater during starting-up periods to avoid overheating of the superheater tubes, and during normal operation to control the final superheat temperature as desired.

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

We claim:

1. A steam boiler having upper and lower vertically spaced banks of horizontally inclined steam generating tubes, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks adjacent one end thereof, baffle means arranged to define a plurality of serially connected upflow and downflow gas passes across said upper bank with said superheater arranged directly below the first upflow gas pass, baffle means arranged to define an upflow heating gas by-pass about said superheater tubes extending substantially vertically across said space and said upper bank and at one side of said superheater, and damper means at the upper end of said by-pass for controlling the gas flow through said by-pass.

2. A steam boiler having upper and lower vertically spaced banks of horizontally inclined steam generating tubes, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks

adjacent one end thereof, baffle means arranged to define a plurality of serially connected upflow and downflow gas passes across said upper bank with said superheater arranged directly below the first upflow gas pass, baffle means arranged to define an upflow heating gas by-pass about said superheater tubes extending substantially vertically across said upper bank and at one side of said superheater, and damper means for controlling the gas flow through said by-pass extending along the uppermost tube row of said upper bank.

3. A steam boiler having upper and lower vertically spaced banks of horizontally inclined steam generating tubes having uptake and downtake connections to the upper and lower ends thereof respectively, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks adjacent the uptake end thereof, baffle means arranged to define an upflow heating gas by-pass about said superheater tubes extending substantially vertically across said upper bank and at one side of said superheater, and damper means for controlling the gas flow through said by-pass extending along the uppermost tube row of said upper bank.

4. A steam boiler having upper and lower vertically spaced banks of horizontally inclined steam generating tubes, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks adjacent one end thereof, baffle means arranged to define a single upflow heating gas pass across said lower bank and a plurality of serially connected upflow and downflow gas passes across said upper bank with the first upflow pass across said upper bank opening to the upflow pass across said lower bank and said superheater arranged in said upflow gas stream, baffle means arranged to define an upflow heating gas by-pass about said superheater tubes extending substantially vertically across said upper bank at one side of said superheater, and pivotally mounted damper means for controlling the gas flow through said by-pass extending along the uppermost tube row of said upper bank.

5. A steam boiler having upper and lower vertically spaced banks of horizontally inclined steam generating tubes having uptake and downtake connections to the upper and lower ends thereof respectively, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks adjacent one end thereof, baffle means arranged to define an upflow heating gas pass across said lower bank and a serially connected upflow gas pass across the uptake end of said upper bank with said superheater arranged between said baffle means and the uptake end of the boiler, baffle means arranged to define an upflow heating gas by-pass between said superheater and said first mentioned baffle means and extending across said upper bank, and damper means at the upper end of said by-pass for controlling the gas flow through said by-pass.

6. A steam boiler having upper and lower vertically spaced banks of horizontally inclined steam generating tubes having uptake and downtake connections to the upper and lower ends thereof respectively, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks adjacent the uptake end thereof, baffle means arranged to define an upflow heating gas pass across said lower bank and a serially connected upflow gas pass across the uptake end of said upper bank with said superheater arranged between said baffle means and the uptake end of the boiler, baffle means arranged to define a substantial vertical heating gas by-pass between said superheater and said first mentioned baffle means and extending across said upper bank, and damper means for controlling the gas flow through said by-pass extending along the uppermost tube row of said upper bank.

7. A steam boiler having upper and lower vertically spaced banks of horizontally inclined steam generating tubes having uptake and downtake connections to the upper and lower ends thereof respectively, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks adjacent the uptake end thereof, baffle means arranged along one side of said superheater and defining a plurality of serially connected upflow and downflow gas passes across said upper bank, baffle means arranged to define an upflow heating gas by-pass about said superheater tubes extending substantially vertically across said upper bank at the downflow side of said first mentioned baffle means, and damper means at the upper end of said by-pass for controlling the gas flow through said by-pass.

8. A steam boiler having a setting rectangular in horizontal cross-section and including upper and lower vertically spaced banks of horizontally inclined steam generating tubes having uptake and downtake connections to the upper and lower ends thereof respectively, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks adjacent the uptake end thereof, baffle means arranged along the downtake side of said superheater and defining a single upflow heating gas pass across said lower bank and a plurality of serially connected upflow and downflow gas passes across said upper bank, baffle means arranged to define an upflow heating gas by-pass about said superheater tubes extending substantially vertically across one corner portion of said setting and said upper bank at the downtake side of said first mentioned baffle means, and damper means for controlling the gas flow through said by-pass.

9. A steam boiler having upper and lower vertically spaced banks of horizontally inclined steam generating tubes having uptake and downtake connections to the upper and lower ends thereof respectively, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks adjacent the uptake end thereof and spaced from the remaining opposite sides of said boiler, baffle means arranged to define upflow heating gas by-passes extending substantially vertically across said upper bank at said opposite sides of said superheater, and damper means for controlling the gas flow through said by-passes.

10. A steam boiler having upper and lower vertically spaced banks of horizontally inclined steam generating tubes having uptake and downtake connections to the upper and lower ends thereof respectively, a steam superheater having a plurality of steam superheating tubes occupying a portion of the space between said tube banks adjacent the uptake end thereof and spaced from the remaining opposite sides of said boiler, baffle means arranged along the downtake side of said superheater and defining a single upflow heating

gas pass across said lower bank and separating upflow and downflow gas passes across said upper bank, other baffle means arranged to define upflow heating gas by-passes about said superheater tubes extending substantially vertically across said upper bank at the upflow side of said first mentioned baffle means and at said opposite sides of said superheater, and damper means for controlling the gas flow through said by-passes.

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