

June 26, 1951

E. MARTIN ET AL
LOCOMOTIVE AND BOILER THEREFOR

2,558,261

Filed May 31, 1944

6 Sheets-Sheet 1

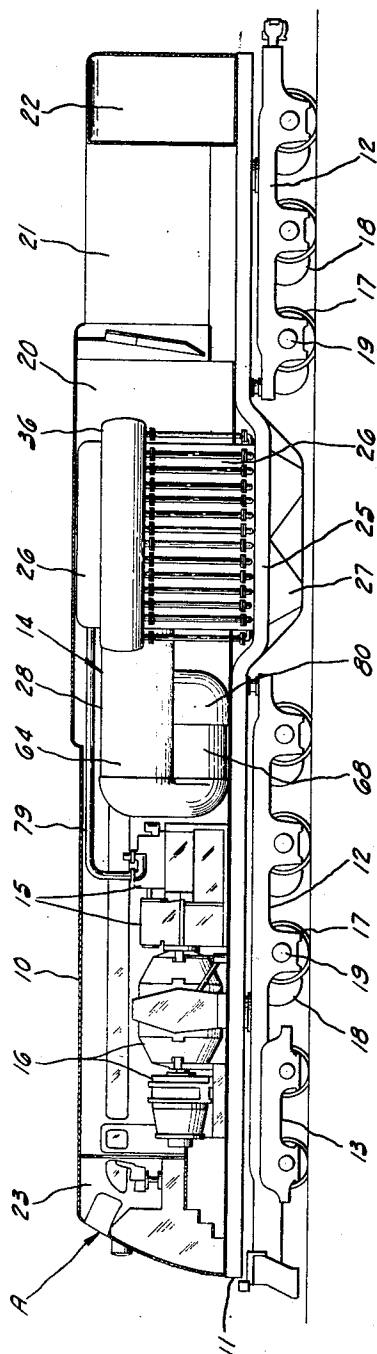


FIG. 1

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6 Sheets-Sheet 2

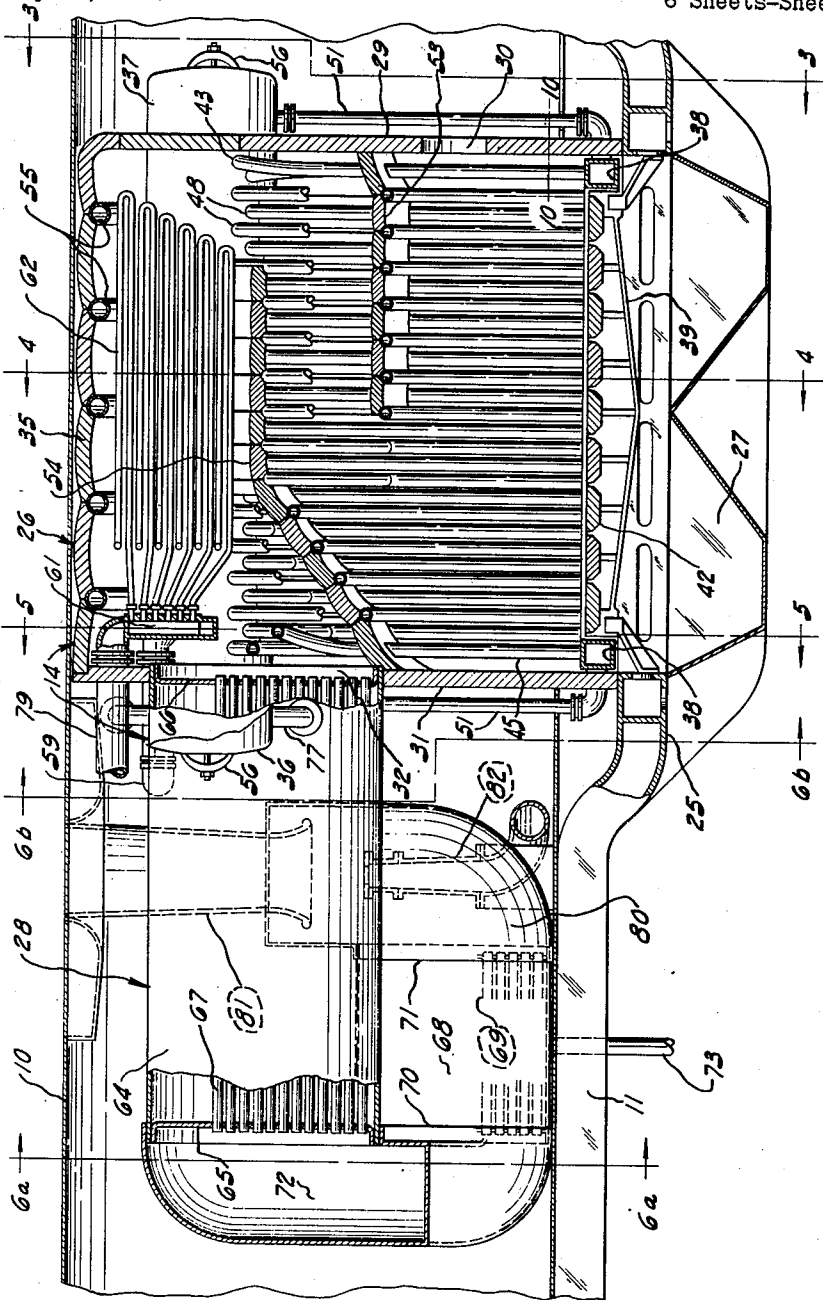


Fig. 2

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6 Sheets-Sheet 3

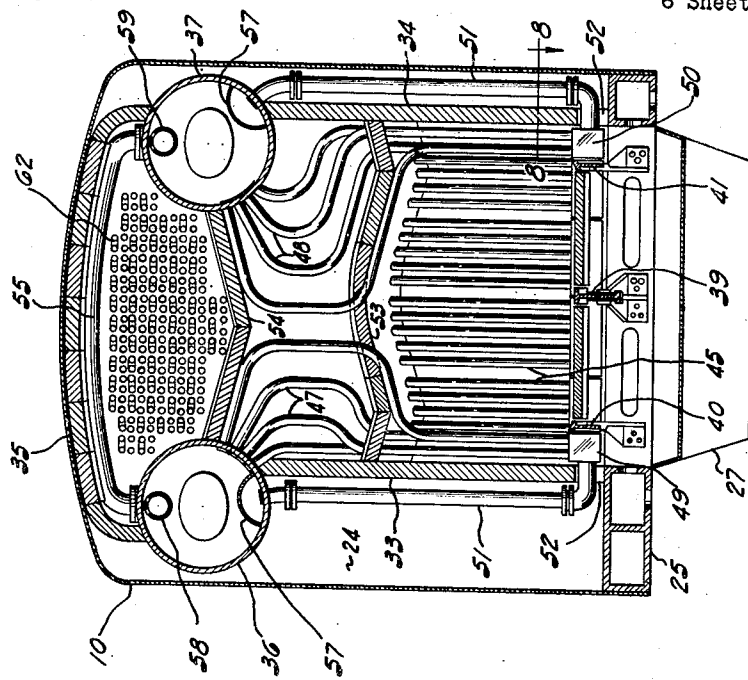


FIG. 4

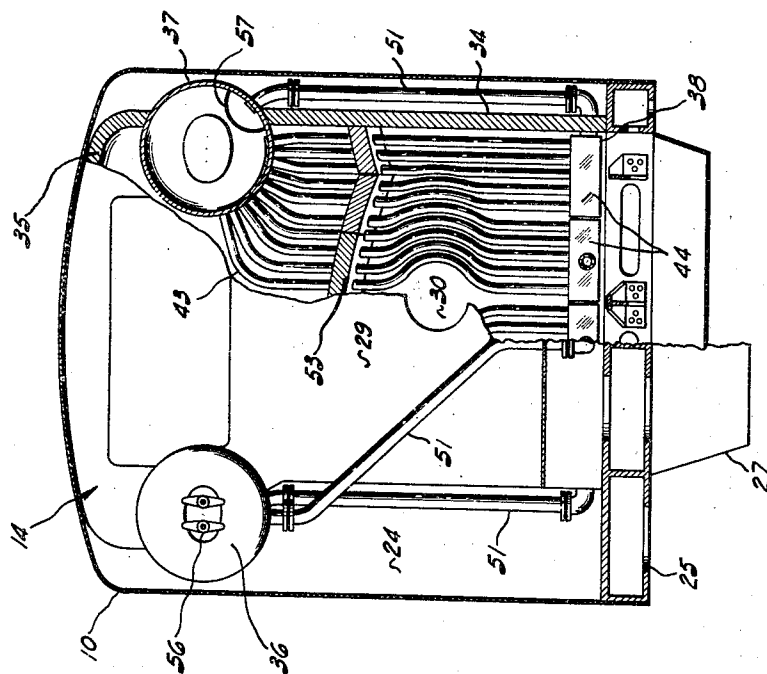


FIG. 3

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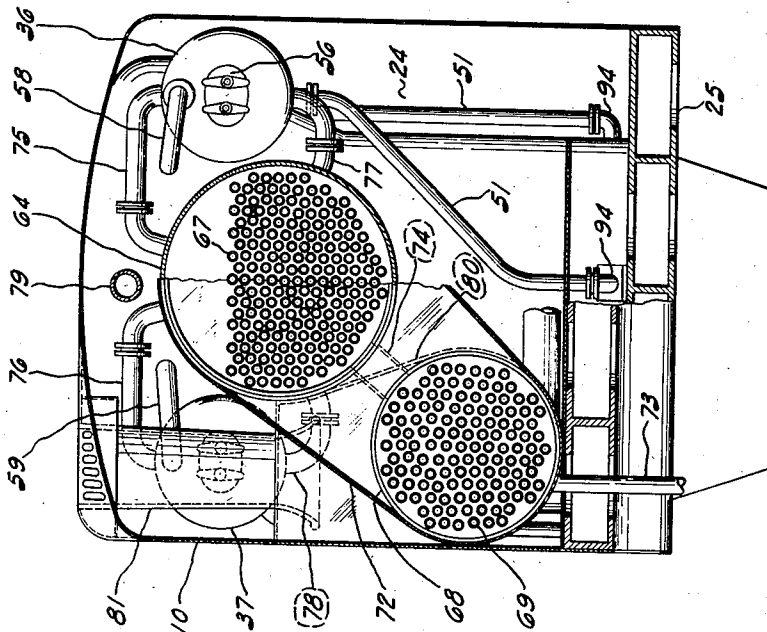


FIG. 6

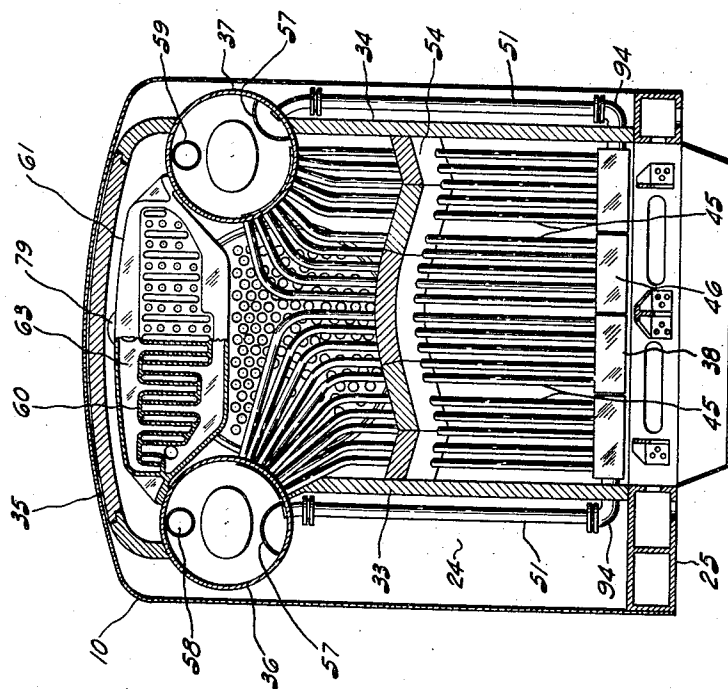


FIG. 5

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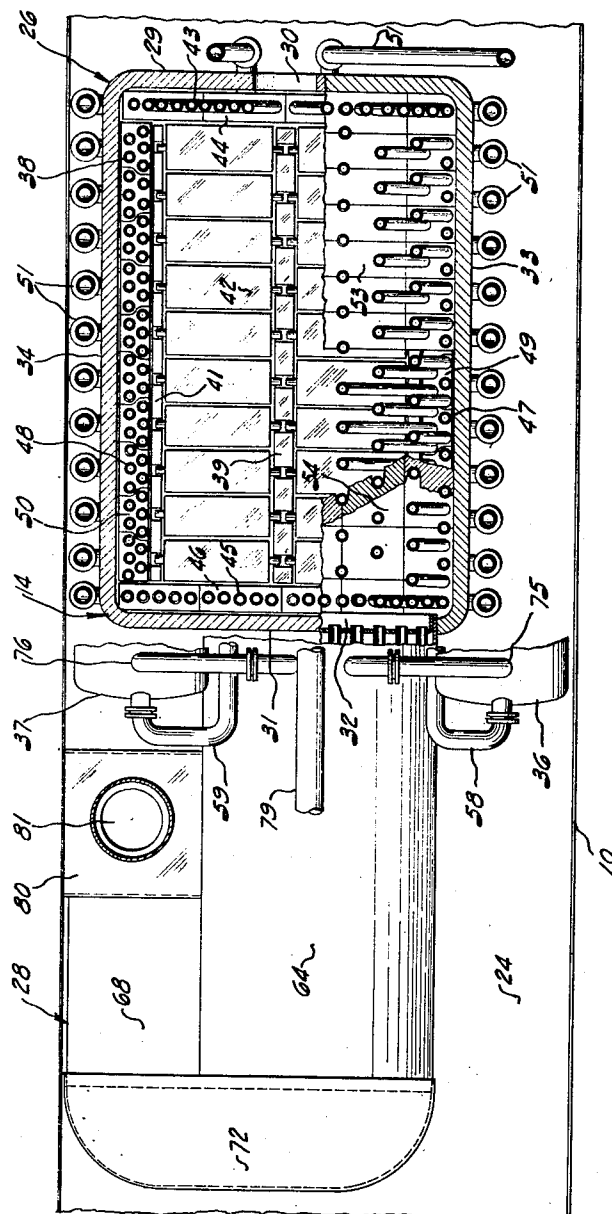
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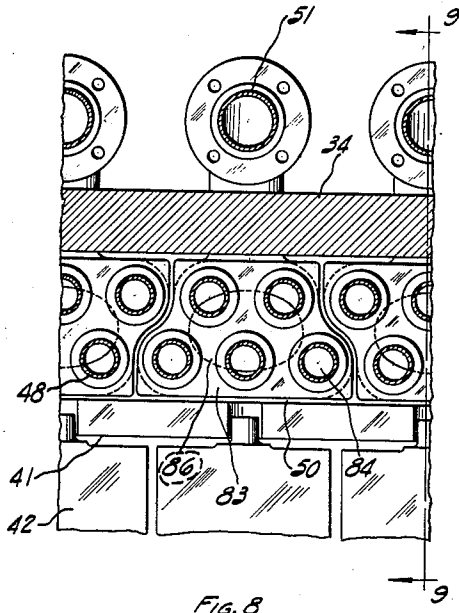


FIG. 8

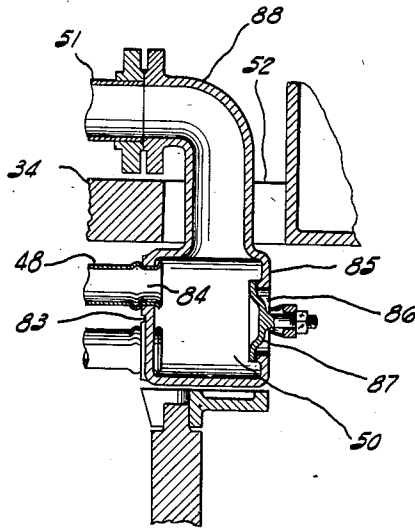


FIG. 9

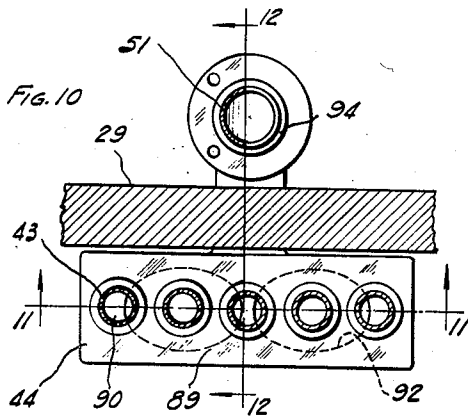


FIG. 10

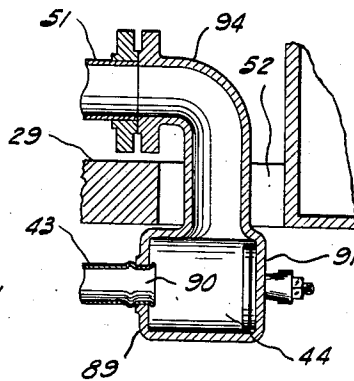


FIG. 12

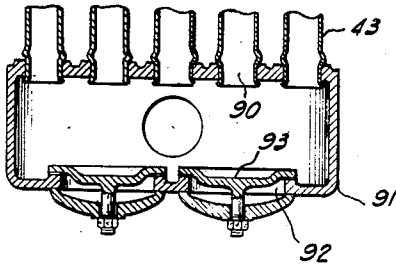


FIG. 11

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UNITED STATES PATENT OFFICE

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LOCOMOTIVE AND BOILER THEREFOR

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Application May 31, 1944, Serial No. 538,164

4 Claims. (Cl. 122-235)

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This invention relates to boilers and more particularly to a boiler especially adapted for use upon locomotives. While the invention is shown and hereinafter described as applied to a locomotive, it will be apparent that it is capable of use in connection with marine, stationary and mobile power plants, and portable installations.

Heretofore the demand for locomotives of increased power were largely satisfied by the development of locomotives approaching the maximum dimensions permitted by road clearances, and further thermal efficiency was obtained by the development and use of auxiliary devices such as feed water heaters, superheaters, etc. An object of our invention is to provide an improved boiler construction whereby it will be possible to obtain locomotives of greater power within the same space limitations than is at present possible. More specifically, an object of the invention is to provide a boiler having an evaporating and superheating capacity which is considerably greater per unit of length than is obtainable in boilers of present construction, and that occupies less space per unit of power delivered.

Another object of the invention is to provide an improved arrangement of the superheater header and elements whereby a very high degree of superheat may be obtained with a minimum fuel consumption, and whereby greater accessibility to the superheater header and elements for inspection and cleaning is provided. More specifically, an object of the invention is the provision of an improved firebox and the arrangement therein of a superheater header and elements whereby the superheater header and elements will be directly subjected to the high temperature combustion gases, and the generated heat will be most economically utilized both in the production of saturated steam in the boiler and in the production of superheated steam.

Another object of the invention is to provide a novel water tube firebox construction whereby the heat produced in the firebox is utilized to greater advantage for rapid steam generation. More specifically, an object of the invention is to provide an improved water tube firebox unit of a locomotive boiler so constructed to cause the major portion of the combustion gases to make three passes therethrough, with a water tube screen disposed in the second pass.

Another object of the invention is to provide a novel water tube firebox construction whereby an adequate circulation of water is assured to all the water evaporating tubes of the firebox. The

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invention further contemplates a novel construction wherein an independent supply of water is provided to each of a plurality of groups of water evaporating tubes.

Another object of the invention is to provide a novel bottom header for a water tube firebox permitting convenient and simple assembling and disassembling thereof and the assembling and disassembling thereof with the water evaporating tubes, water feeding tubes and other parts of the water tube firebox.

Other objects and advantages of the invention will become apparent from the following description, a preferred embodiment of which is illustrated in the accompanying drawings, wherein

Fig. 1 is a longitudinal vertical central section through a locomotive embodying the invention, the novel boiler and other parts being shown in side elevation;

Fig. 2 is a longitudinal vertical central section through the novel boiler and a portion of the locomotive illustrated in Fig. 1, parts being shown in elevation;

Fig. 3 is a sectional view through the locomotive taken on the line 3-3 of Fig. 2, with a portion of the locomotive boiler backhead broken away and parts shown in section;

Fig. 4 is a vertical transverse section taken on the line 4-4 of Fig. 2;

Fig. 5 is a vertical transverse section taken on the line 5-5 of Fig. 2 with a portion of the superheater header shown in elevation;

Fig. 6 is a composite vertical transverse section, the left half of which is taken on the line 6a-6a of Fig. 2, and the right half of which is taken on the line 6b-6b of Fig. 2;

Fig. 7 is a plan view of the boiler shown in Fig. 2 with parts broken away and shown in section;

Fig. 8 is a fragmentary sectional view taken on the line 8-8 of Fig. 4, showing the side members of the rectangular sectional bottom header;

Fig. 9 is a sectional view taken on the line 9-9 of Fig. 8;

Fig. 10 is a fragmentary sectional view taken on the line 10-10 of Fig. 2 showing one of the rear members of the rectangular sectional bottom header;

Fig. 11 is a sectional view taken on the line 11-11 of Fig. 10; and

Fig. 12 is a sectional view taken on the line 12-12 of Fig. 10.

Referring to Fig. 1, which shows a preferred embodiment of the invention, a turbo-electric

locomotive is represented generally by the letter A. It is provided with an external shell 10 supported on a frame 11 which in turn is mounted on the two six wheel trucks 12. A lead truck 13 is associated with the foremost of the two six wheel trucks 12.

Within the shell 10 is mounted the steam generating plant or boiler 14 and turbo-electric generating means operable by steam from the boiler 14. The turbo-electric generating means comprises the turbine and gear set 15 and the generator and exciter 16. All of the wheels 17 of the two six wheel trucks 12 are preferably utilized as drive wheels, and each pair of them is provided with a driving motor 18, the driving motors being operable by current from the turbo-electric means 15, 16, and being suitably supported on the truck frames and suitably geared to the axles 19 of the wheel trucks.

At the rear of the boiler 14 is a space 20 for the fireman and to the rear of this is a coal bin 21 and a water tank 22. The engineers cab 23 is located at the forward end of the locomotive and a passageway 24, shown in Figs. 3 to 7, inclusive, extends from the cab 23 along the side of boiler 14 to the fireman's space 20 and thence along the side of the coal bin 21 and water tank 22.

The trucks 12 are spaced apart, as shown in Fig. 1, and that part of the frame 11 lying therebetween is depressed, as at 25. The firebox unit 26 of the boiler 14 is mounted on the depressed portion 25 of the frame and an ash pan 27 for the firebox unit 26 depends therefrom in the space between the trucks 12. It will be seen that this construction and arrangement of elements provides for a firebox of maximum overall height without increasing the height of the top of the firebox above the level of the rails. This increased overall height provides greater evaporating surface in the firebox unit of the boiler thereby making it possible to materially shorten the overall length of the boiler as compared with the usual locomotive steam boiler.

The novel boiler 14 comprises the firebox unit 26 which is of the water tube evaporating type, and a fire tube evaporating unit 28. The firebox unit 26 is defined by rear wall 29 having a firing opening 30, front wall 31 having a combustion gas outlet 32, side wall 33, side wall 34 and top wall 35, said walls being made of refractory or other suitable material. A pair of laterally spaced drums 36 and 37 extend longitudinally through the upper portion of the firebox unit 26 and are supported by the rear and front walls 29 and 31, respectively. At the bottom of the firebox and following closely along the inside surface of the firebox walls 29, 31, 33 and 34 is a rectangular shaped bottom header 38, preferably formed in a plurality of sections as best shown in Figs. 7, 8 and 10 and as described hereinafter in detail. A center grate bearer bar 39 and side grate bearer bars 40 and 41, best shown in Figs. 2, 4 and 7, are secured to the depressed portion 25 of the frame 11 and support the firebox grate sections 42.

A bank of upright water tubes 43 extends across the rear of the firebox 26 closely adjacent the rear wall 29 and connects the drums 36 and 37 with the rear sections 44 of the rectangular bottom header 38. As seen in Fig. 3, the centrally disposed tubes 43 are arcuately curved at the firing openings 30 to provide an unobstructed aperture.

A bank of upright water tubes 45 extends across

the front of the firebox 26 closely adjacent the front wall 31 and connects the drums 36 and 37 with the front sections 46 of the rectangular bottom header 38, as seen in Fig. 5.

A bank of upright water tubes 47 extends across one side of the firebox 26 and another bank of upright water tubes 48 extends across the opposite side of the firebox 26. The banks of water tubes 47 and 48 connect drums 36 and 37, respectively, with the side sections 49 and 50, respectively, of the rectangular bottom header 38, as seen in Fig. 4. The lower portions of water tube banks 47 and 48 are disposed adjacent the respective side walls 33 and 34, and the upper portions of the water tube banks 47 and 48 are bent inwardly toward each other. The water tubes 47 and 48 are bent inwardly varying distances so that a water tube screen is formed extending across the firebox for substantially its full length intermediate the top and bottom of the firebox. The water tube banks 47 and 48 are each arranged with their lower portions in a staggered double row as best illustrated in Figs. 7 and 8, so that a greater number of tubes can be provided on each side of the firebox than if arranged in a single row. By staggering the rows, they can be arranged closer together than they could otherwise.

By means of the construction described above, wherein closely spaced water evaporating tubes present a continuous surface on all sides of the firebox and a screen of water tubes extends longitudinally through the central portion of the firebox, it will be seen that a large evaporating surface is provided whereby a maximum amount of heat is absorbed by radiation.

In view of the extremely high evaporating capacity of our improved water tube firebox, it is important that there be a free and extremely rapid circulation. This is provided for in our construction by a plurality of downcomers 51 that communicate at their upper ends with the drums 36 and 37 and extend downwardly along the exterior of the walls 29, 31, 33 and 34 and that project at their lower ends through openings 52 to communicate with the rectangular bottom header 38. One downcomer communicates with each of the sections 44, 46, 49 and 50 of the bottom header 38 and a plurality of water evaporating tubes, preferably five as shown, communicate with each of the bottom header sections 44, 46, 49 and 50. Each group of five water evaporating tubes thus has its own water supply downcomer, thereby assuring an adequate water circulation in all parts of the water tube firebox.

In order to provide maximum utilization of the hot combustion gases in the water tube firebox unit 26 for conversion of water to steam, three passes for the major portion of the combustion gases are arranged within the firebox unit. A transverse wall or baffle 53 extends from one side wall 33 to the opposite side wall 34 and projects forwardly into the firebox from the rear wall 29 just above the level of the firing opening 30, terminating at its forward end short of the firebox front wall 31. The baffle 53 is formed by a plurality of refractory bricks and is supported by the water tubes 47 and 48, as best shown in Fig. 4.

A second transverse wall or baffle 54 extends from one side wall 33 to the opposite side wall 34 and projects into the firebox from the front wall 31 just below the level of the combustion opening 32, rearwardly above the baffle 53 and terminates at its rearward end short of the rear wall 29, as seen in Fig. 2. The baffle 54 is formed

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by a plurality of refractory bricks and is supported by the water tubes 47 and 48, as seen in Fig. 4.

The overlapping baffles 53 and 54, as best shown in Fig. 2, form a tortuous passage in the firebox extending from the firing opening 30 to the combustion gas outlet 32 causing the major portion of the combustion gases to make three passes through the firebox. The water tube screen formed by the inwardly bent portions of the water tubes 47 and 48, previously described, extends throughout the second pass between the baffles 53 and 54. The forward end of the baffle 54 slopes downwardly, as shown in Fig. 2, and the water tubes 47 and 48 at the forward end of the firebox preferably extend through the sloping portion of the baffle 54 to form a water tube screen in the lower forward end of the third or uppermost pass.

A plurality of transversely extending equalizing tubes 55, best shown in Figs. 2 and 4 provide communication between the drums 36 and 37 and serve to equalize the steam pressure in the drums. The tubes 55 preferably form a support for the refractory bricks forming the top wall 35 of the firebox unit 26.

The drums 36 and 37 are provided at each of their ends with a manhole normally closed by a manhole cover or plate 56, removal of which provides access to the interior of the drums for cleaning, repairs, inspection and other purposes. Since the point of entrance of the water evaporating tubes 43, 45, 47 and 48, to the drums 36 and 37 is below the normal water level therein, the discharge of steam into the drums 36 and 37 will be quite violent. In order therefore to assure an uninterrupted and steady flow of water to the downcomers 51, a plate 57, arcuate in cross section, is provided in each of the drums 36 and 37. The arcuate plates 57 extend longitudinally in the drums over points of entrance of the downcomers 51 into the drums 36 and 37, and terminate at their ends short of the respective ends of the drums. Water thus flows under the plates 57 from the comparatively quiet ends of the drums 36 and 37 to the entrance to the downcomers 51.

Saturated steam is taken off from the upper ends of the drums 36 and 37 through return bend pipes 58 and 59, respectively, as seen in Figs. 6 and 7, and is delivered to the saturated steam chamber 60 of the superheater header 61, as shown in Figs. 2 and 5. From the saturated steam chamber 60 the steam passes through the superheater tubes 62, Figs. 2 and 4, and thence to the dry steam chamber 63, Fig. 5, of the superheater header 61. From dry steam chamber 63, the superheated steam passes through pipe 79 to the turbine 15. The superheater, comprising the superheater header 61 and superheater tubes 62 is disposed in the third or uppermost pass of the firebox.

Since the superheater header 61 and tubes 62 are located in the firebox end of the boiler, a higher degree of superheat is obtained for all ratings than is possible with the conventional arrangement of the superheater header in the smoke box and the superheater tubes projecting rearwardly in the forward ends of the fire tubes. In the conventional locomotive arrangement it is impossible to obtain a very high degree of superheat without maintaining an abnormally high temperature in the smoke box. Our improved boiler makes it possible to obtain a high degree of superheat while at the same time permitting maintenance of a relatively low smoke box

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temperature, whereby a greater utilization of the heat generated in the firebox is realized for the purpose of evaporation.

While, as described above, the superheater header 61 and tubes 62 are located in the firebox unit, injury thereto by excessive heat is minimized by reason of the large and efficient heat absorbing surface provided in our improved firebox construction and the location of the superheater in the third pass of the combustion gases through the firebox, whereby the temperature of the combustion gases when they reach the superheater while sufficiently high to produce a high degree of superheat, is not excessive.

The firetube evaporating unit 28 of the boiler 14 includes a water containing and steam generating barrel 64 which is in substantial register at its rearward end with the combustion gas outlet 32 of the firebox unit 26 and extends forwardly therefrom. The forward and rearward ends of the barrel 64 are provided with the front and rear tube sheets 65 and 66, respectively, as best shown in Fig. 2. The barrel 64 contains a plurality of closely spaced longitudinally extending fire tubes 67 projecting through and being supported by the tube sheets 65 and 66, through which tubes pass combustion gases from the firebox.

In order to abstract as much heat as possible from the combustion gases passing through the fire tubes 67, it is important to provide the largest possible area of heating surface. In the conventional types of locomotive boilers wherein the superheater tubes extend into the fire tubes, the fire tubes must of necessity have a relatively large diameter in order to accommodate the superheater tubes. In our construction and arrangement of parts the superheater tubes do not extend into the fire tubes so that a large number of small diameter fire tubes instead of a smaller number of large diameter fire tubes are used. Since these small diameter fire tubes provide a total heating surface considerably greater than would the number of conventional large diameter tubes that could be accommodated in a barrel of the same diameter, it is apparent that in our construction a barrel of comparatively shorter length can be used in abstracting useful heat for evaporating purposes.

A second barrel 68 is located below and offset to one side of the main barrel 64, on that side of the locomotive opposite the passage 24, as seen in Fig. 6. The forward end of the barrel 68 is in line with the forward end of the barrel 64, and the rearward end thereof terminates short of the rearward end of the barrel 64 and short of the front wall 31 of the firebox unit 26. The barrel 68 contains a plurality of closely spaced small diameter fire tubes 69 which project through and are supported by the front and rear tube sheets 70 and 71, respectively, of the barrel 68.

A flue chamber 72 connects the forward ends of the barrels 64 and 68 providing for passage of the combustion gases from the fire tubes 67 to the fire tubes 69. The useful heat for evaporating purposes is expended by the combustion gases in the improved firebox unit 26 and the barrel 64 and the remaining useful heat of the combustion gases is abstracted in the barrel 68 which functions as a feedwater heater. Water is delivered to the barrel or feedwater heater 68 from the tank 22 by a feedwater conduit 73 as shown in Fig. 2, and from the feedwater heater 68, water passes to the barrel 64 through a number of connecting passages 74, as shown in Fig. 6.

The steam liberated in the barrel 64 is taken off at the top rear thereof through steam pipes 75 and 76, which as shown in Figs. 6 and 7 connect with the top front of the steam and water drums 36 and 37 respectively. The steam liberated in the barrel 64 thence passes along with the steam liberated in the firebox unit 26, from the drums 36 and 37 to the superheater header 61 through the pipes 58 and 59 as previously described. Water for the firebox unit 26 of the boiler 14 is delivered to the forward under side of the drums 36 and 37 from the rear lower side of the barrel 64 through pipes 77 and 78, respectively.

The fire tubes 69 of the feedwater heater or barrel 68 open into a smoke box 80 which extends upwardly at one side of the barrel 64 on the side of the locomotive opposite the passage 24, as best seen in Figs. 2 and 6. The stack 81 extends from within the upper end of the smoke box 80 upwardly through the outer shell 16 of the locomotive. Drafting of the firebox 26 is accomplished by means of a nozzle 82 disposed within the smoke box 80 and through which nozzle 82 steam from the turbine 15 is exhausted to atmosphere from the stack 81.

As stated above the rectangular bottom header 38 of the firebox unit 26 is preferably formed of a plurality of sections, the front water leg thereof comprising sections 43, the rear water leg comprising sections 44 and the longitudinal side water legs comprising sections 49 and 50, as shown in Fig. 7. In Figs. 8 to 12 inclusive, these sections are shown in greater detail. The sections 49 are the same as sections 50, the latter being illustrated in Figs. 8 and 9, and the sections 46 are the same as sections 44 which latter sections are illustrated in Figs. 10, 11 and 12.

The sections 49 and 50 are in the form of hollow castings, each having a top wall 83 provided with a plurality of openings 84, preferably five, in a staggered double row arranged to receive the lower ends of the water tubes 47 and 48. Each of the sections 49 and 50 also has a bottom wall 85 provided with an oval shaped opening 86 normally closed by a cover plate 87. When the cover plate 87 is removed, the opening 86 provides access to the exposed ends of the water tubes, allowing the ends of the tubes to be rolled and beaded in and permitting the tubes to be cleaned or washed out.

The end walls of the sections 49 and 50 converge so that each of the sections has a narrow side and a wide side, the narrow side having a row of two openings 84, and the wide side having a row of three openings 84. The sections 49 and 50 when assembled are arranged with the narrow and wide sides alternately facing outwardly. Each of the sections 49 and 50 is provided with an integrally formed 90 degree elbow 88 forming the lower portion of the downcomers 51. Some of the sections 49 and 50 have the elbow 88 projecting outwardly from their narrow side and some have the elbow 88 projecting outwardly from their wide side, so that when assembled, all the elbows 88 are arranged to project outwardly through the openings 52 in the walls 33 and 34.

The sections 44 and the sections 46 which are the same as sections 44, have a rectangularly shaped top wall 89 provided with a plurality of openings 90, preferably five, in a single row arranged to receive the lower ends of the water tubes 43 and 45. The bottom walls 91 of the sections 44 and 46 are provided with a pair of oval shaped openings 92 normally closed by cover

plates 93. When the cover plates 93 are removed, the openings 92 provide access to the exposed ends of the water tubes, allowing the ends of the tubes to be rolled and beaded in and permitting the tubes to be cleaned or washed out. Each of the sections 44 and 46 is provided at one side thereof with an integrally formed 90 degree elbow 94 projecting outwardly through the openings 52 in the walls 29 and 31 and form the lower portion of the downcomers 51.

We claim:

1. A locomotive boiler comprising a firebox, means in said firebox forming three passes therethrough for the combustion gases, a water tube evaporating unit for said firebox including steam and water header means at the top of the firebox, water supplying header means at the bottom of the firebox, banks of water tubes at the sides of said firebox connecting said steam and water header means and said water supplying header means, each bank comprising a plurality of spaced individual tubes including water tubes of each bank arranged in each of said passes and all tubes disposed in at least two passes so that all of the tubes are subjected to the action of said combustion gases at least twice during the passage of the gases through said firebox.

2. A locomotive boiler comprising a firebox comprising a pair of transverse vertically spaced overlapping baffles in said firebox projecting inwardly respectively from opposite ends thereof forming a continuous tortuous passage therethrough defining three passes for the combustion gases, a water tube evaporating unit for said firebox including steam and water header means at the top of the firebox, water supplying header means at the bottom of the firebox, banks of water tubes at the sides of said firebox connecting said steam and water header means and said water supplying header means, each bank comprising a plurality of spaced individual tubes including water tubes of each bank arranged in each of said passes and all tubes disposed in at least two passes so that all of the tubes are subjected to the action of said combustion gases at least twice during the passage of the gases through said firebox.

3. A water tube firebox comprising steam and water containing means at the top of the firebox, headers at the bottom of the firebox, a bank of water tubes at each side of the firebox, each of said banks providing communication between said water containing means and a respective side header, said banks of water tubes extending vertically throughout the firebox and each bank of tubes being bent inwardly toward the center of said firebox to provide a series of transversely spaced longitudinal rows of tubes in each of said banks of tubes and a pair of transversely vertically spaced overlapping baffles in said firebox including therebetween said bent portions of said tubes and on which said baffles are supported, said baffles projecting inwardly respectively from opposite ends of said firebox forming a tortuous passage causing the major portion of the combustion gases to make three passes through said firebox.

4. A water tube firebox comprising steam and water containing means at the top of the firebox, headers at the bottom of the firebox, a bank of water tubes at each side of the firebox, each of said banks providing communication between said water containing means and a respective side

header, said banks of water tubes extending vertically throughout the firebox and each bank of tubes being bent inwardly toward the center of said firebox to provide a series of transversely spaced longitudinal rows of tubes in each of said banks of tubes, and a pair of transverse vertically spaced overlapping baffles in said firebox including therebetween said bent portions of said tubes said rows of tubes forming a support for said baffles, said baffles projecting inwardly respectively from opposite ends of said firebox forming a tortuous passage causing the major portion of the combustion gases to make three passes through said firebox and a superheater disposed in the uppermost of said passage.

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