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HIGH PRESSURE WATER TUBE BOILER FOR LOCOMOTIVES

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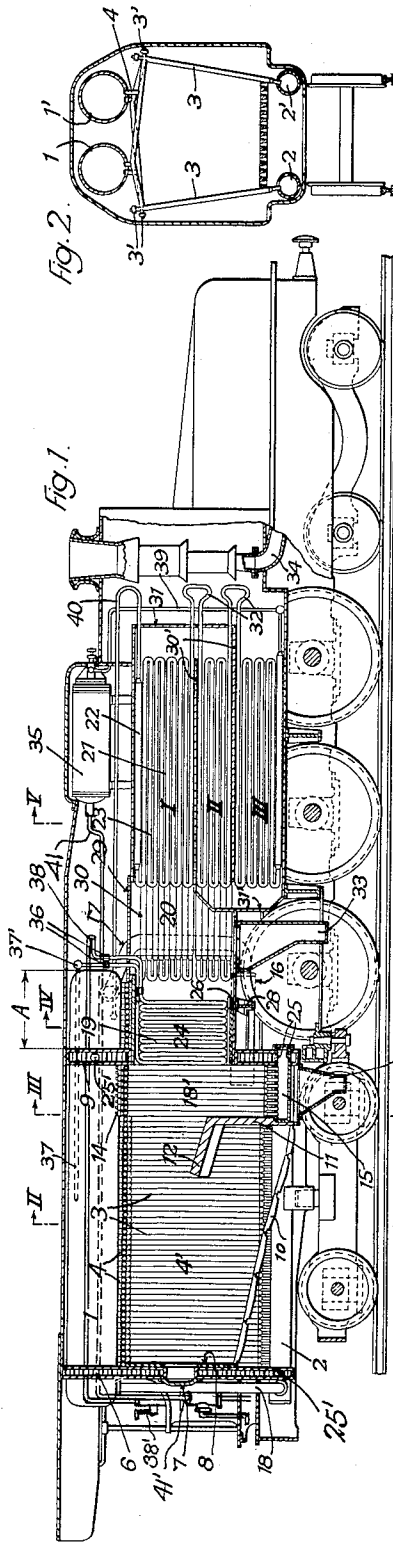


Fig. 2.

Fig. 1.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 10.

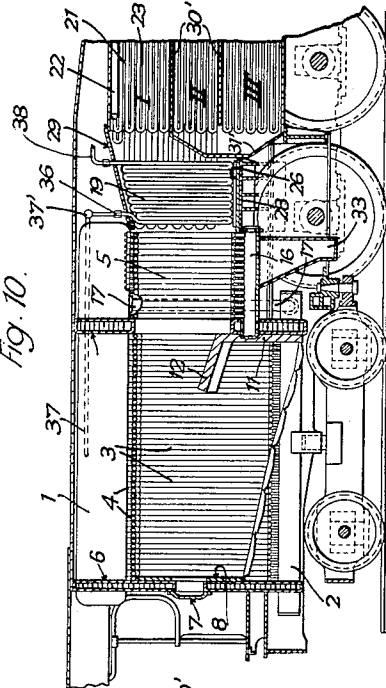


Fig. 8.

Fig. 7.

Fig. 9.

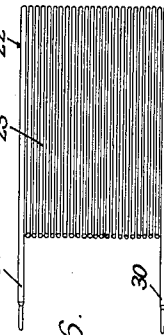
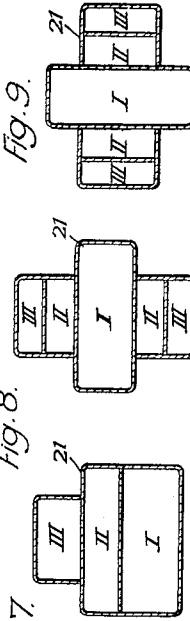


Fig. 6.

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HIGH PRESSURE WATER TUBE BOILER FOR
LOCOMOTIVESHans Nyffenegger, Winterthur, Switzerland, as-
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With high pressure water tube boilers, particularly for locomotives, the arrangement of the heating surfaces with a view to obtain a heating effect of the combustible gases as great as possible becomes a matter of considerable difficulty. It is obvious with the process of evaporation that in order to render the efficiency of the boiler as great as possible the heating surface in contact with the water is best separated in two main parts. In a first part, i. e. in the flue gas heated feed water preheater a proportion of heat as great as possible should be transmitted to the feed water which almost suffices to heat the water up to the boiling point which corresponds to the pressure existing in the boiler and this is preferably effected in a counter flow between the feed water and the flue gases with the temperature of the latter gradually decreasing. In a second part it is essential that the heat to be transmitted, corresponding to the evaporation taking place at substantially constant temperature, is emitted by the combustible gases at a temperature as constant as possible i. e. the heat for evaporation is to be transmitted in the fire box heated by the flames set up on the grate and the radiating gases. I have found by tests that the best exploitation of the flue gases is reached when the relation of the sum of the heating surfaces of the fire box and the combustion chamber to the total heating surface in contact with the water of the boiler is about 1:7.

In a third part of the heating surface, i. e. the superheater, the wet steam generated in the boiler is suitably transformed, by means of further heat transmission into superheated steam. Thus, corresponding to the high temperature for the superheated steam to be obtained the highest in the whole process of evaporation, the superheater ought to be arranged in the highest region of the heating space. In respect of the limited cooling effect of the superheated steam, however, and absence of any cooling effect when the withdrawal of the steam is effected in a closed chamber, it is impossible without the aid of special auxiliary means to arrange the superheater in this manner. But in order to distribute the means participating in the exchange of heat over the temperature regions in the most suitable manner, the superheater is preferably so inserted in the stream of the combustible gases that, at least when the steam withdrawal is stopped, it is protected against the intensive heat radiation from the combustion chamber but heated by the hottest gases emanating from the fire box or

the combustion chamber respectively by surface contact.

The design of the steam generator is, however, not only dependent on the above-mentioned requirements of the theory of firing and heat transmission, but also on the theory of circulation (water circulation), constructional reasons and requirements for cleaning purposes. Moreover, particularly with locomotives, the weight, space requirements and cost of production play a decisive role.

The object of the present invention is to satisfy all the above-mentioned requirements, by so designing the fire box as to permit the transmission into the water of approximately that amount of heat necessary for generating the total amount of steam in the boiler, at the boiling point of the water corresponding to the steam pressure. This is accomplished by providing a relation between the total heating surface of the fire box covering sheet, inclusive of that of the combustion chamber and the total heating surface of the boiler in contact with the water, which approximates the ratio 1:7.

With the proportions of these parts of the boiler according to the invention approximating the said ratio the requirements for heat distribution in the boiler as explained above are, as tests have shown, automatically met, the distribution of the heat admitted to the boiler water depending for a certain constructional arrangement solely on the proportions of the respective parts.

The invention is schematically illustrated in the accompanying drawing in several constructional forms, by way of example only, in which:

Fig. 1 is a vertical longitudinal section of the boiler in assembly with a locomotive;

Fig. 2 is a section through the fire box on the line II—II in Fig. 1;

Fig. 3 is a section through the combustion chamber on the line III—III in Fig. 1 ahead of the fire bridge;

Fig. 4 is a section on the line IV—IV in Fig. 1 through the superheater;

Fig. 5 is a section on the line V—V in Fig. 1 through the preheater;

Fig. 6 shows a top plan view of the preheater;

Figs. 7 to 9 show diagrams for different modifications of the preheater, and

Fig. 10 is a fragmentary vertical section similar to Fig. 1 showing a modified form of the boiler. Referring to the drawing the general designations for all the figures are 1 and 1' for the steam collecting drums (upper drums), 2 and 2' 110

for the lower or water drums, 3 are the inverted U-shaped tube elements of the fire box and 4 the pipe connections of these elements to the upper drums. The U-shaped tube elements of the superheating chamber are designated by 5 and by 6 the rear end wall including the firing door 7 and the protective lining 8. By 9 the forward end wall is designated and 10 refers to the grate. 11 denotes the fire brick partition wall including the refractory arch 12. 13 are the water tubes of the combustion chamber 18' which are connected by the tubes 14 to the stub drum 15. The tubes 13 and 14 provide branch tubes between the upper and lower drums 1, 1' and 2, 15, 2' respectively. 16 and 16' denote short water drums inserted in the forward end wall and connected by water circulation tubes 17 to the drums 1, 1', whilst the water circulation pipes 18 interconnect the drums, 1, 1' and 2, 2'. 19 designates the superheater, 20 the chamber for disassembling purposes, 21 the feed water preheater, and 22 exterior and 23 interior preheater tubes.

Fig. 1 shows a high pressure water tube boiler mounted in a locomotive which comprises the two large upper steam collecting drums 1, 1' and the two lower or water drums 2, 2' which are disposed laterally of the grate. The upper drums communicate with the lower drums by the rearward water circulation tubes 18. A great number of closely packed vertically arranged U-shaped tubes 3, which are assembled in a known manner, form a shell for the fire box, the top sheet or ceiling of which protects the upper drums against being heated. The U-shaped tube elements are connected to the lower drums 2, 2' by beads on their lower ends, and their tubular transverse members, forming the top sheet of the fire box 4' communicate by means of the two short pipe connections 4 with the two upper drums for discharging the steam generated in the tube elements into the two upper drums. The individual tube members of the U-shaped evaporating elements 3 can be mechanically cleaned through apertures adapted to be closed by screw caps 3' in the corner connections. The rear end wall 6 of the fire box is formed in a manner known per se by a water filled double plate water header, which is rigidly connected to the drums, and the plates of which are stiffened by staybolts or sleeves respectively and which carries the firing door 7. As it is impossible to clean the surfaces of the double plate walls which are in contact with the water mechanically from depositing incrustations, these walls are provided with a lining 8 on the furnace side for protecting the wall from being overheated, so that no particles that are apt to form incrustations are given an opportunity of binding on the metal. The forward end wall 9 of the fire box or water header is constituted by a double plate wall similar to the wall 6 and is formed with a large aperture providing sufficient free passage for the gases to escape from the fire box. The forward double plate wall 9 is set back from the forward ends of the drums 1, 1' in substantial manner, i. e. for the distance A which is at least the length of the superheater 19. The double plate walls serve as supports for the two upper drums 1, 1' and to a certain extent also as water returns for facilitating the water circulation, both plate walls communicating with the upper and lower drums 1, 1' and 2, 2' respectively, as shown at 25'. The grate 10 in the fire box slants considerably forwardly so that its forward end extends down to the level of the lower drums 2, 2'. The forward end of the grate ad-

joins the partition wall 11 of fire brick which serves at the same time as a support for the refractory arch 12. In the space between this supporting wall for the refractory arch and the forward double plate wall 9, i. e. the space which corresponds to the combustion chamber of great low pressure locomotive boilers and which for high pressure boilers forms an annex to the fire box, three additional longitudinal rows of steeply ascending water tubes are arranged, the two outer rows 13 of which are fed from the lower drums, their upper ends communicating with the top tube elements of the fire box or the connecting pipes between these elements and the upper drums respectively. The middle row 14 of water tubes is fed from a small stub drum 15, the forward end of which is jointed with the forward double plate wall, and the steam generated in said row of tubes is delivered to the tube element forming the top sheet of the fire box at the mid point of these elements. As in the combustion chamber 18' the heat radiation is considerably diminished the generated steam has sufficient free passage for flowing to the upper drums. The additional water tubes in the combustion chamber tend to diminish the heat radiation between the fire box and the superheater and are adapted to be mechanically cleaned partly from the upper drums and partly through apertures provided in the tube elements of the top sheet of the fire box adapted to be closed by threaded caps 13', 14'.

The heating surface of the fire box inclusive of the combustion chamber is so designed as to permit the transmission into the water of approximately that amount of heat necessary for generating the total amount of steam of the boiler at the boiling point of the water corresponding to the steam pressure. The fire box designed from this point of view produces due to its size relatively lower temperatures, which with a view to safeguarding the heating surfaces as much as possible is very desirable. The relatively large combustion chamber 18' which produces a relatively low speed of the combustion gases promotes the combustion of fine coal particles which may have been carried off. After leaving the fire box 4' and the combustion chamber 18' the heating gases enter the superheating chamber 24. The latter is formed in similar manner as the covering sheet of the fire box by U-shaped tube elements 5. These tube elements join at the bottom with the two short drums 16, 16' which are connected to the forward plate wall 9 and which are disposed on a somewhat higher level and eventually further away from the middle than the lower water drums 2, 2' of the fire box 4'. The U-shaped tube elements of the superheating chamber 24 are connected in similar manner as the tube elements of the fire box 4' with the large upper drums 1, 1'. The lateral water tube elements of the superheating chamber serve as circulation tubes for the water. Two large circulation tubes 17 which connect the forward ends of the upper steam collecting drums 1, 1' with the short drums 16, 16' serve also as circulating tubes. In order to be able to intensify the circulation, the water tubes 5 of the superheating chamber 24 may be protected by a heat insulating lagging against heating.

Unless otherwise required by constructional reasons the circulation tubes are vertically arranged, i. e. so as to provide the shortest bridge between the drums. The drums are apertured at the places where they pass through the water

space of the double plate walls as at 25 so as to increase the section of free passage for the water circulation as much as possible.

The superheater 19 is arranged in the above-described superheater chamber 24 and constructed as a cross-stream heat exchange device including vertical tubes. At the top it is removably connected at 36 on the one hand to a steam collecting piping 37 for conducting the steam from the upper drums 1, 1' to the superheater and including a control valve 37' and on the other hand to a pipe 38 leading to the throttle valve 38'. It rests on a longitudinal slide or track or as shown on a roller grate 26 connected to the bottom 27 of this chamber which in turn is suspended from the short drums 16, 16' by means of a carrier 28. The weight of the superheater transmitted to the short drums 16, 16' is transferred to the steam collecting drums 1, 1' by the shell of the boiler. The superheater which is detachably arranged is adapted to be shifted as a whole towards the front into the chamber 20 for disassembling purposes and after removal of the cover 29 ahead of the steam collecting drums 1, 1' the superheater 19 may be taken out of the boiler if desired. In this manner large areas of free passage are provided to give convenient access to the superheater chamber 24, combustion chamber 18', fire box 4', and the forwardly disposed flue gas feed water preheater 21. The superheater 19 may be placed further forwardly in the superheater chamber (see Fig. 10) and the space thus made available in the superheater chamber equipped with water tubes similar to those in the combustion chamber. With this arrangement the carrier 28 is directly connected to the frame of the locomotive.

The flue gas feed water preheater 21 is subdivided into a number of regions consecutively connected with each other for conducting the flue gases in longitudinal planes in a counter flow to the feed water. The hottest region I of the preheater (see Fig. 1) is disposed with its upper edge substantially at the same level as the upper edge of the superheater chamber 24. The second or middle region II of the preheater is positioned beneath the first region and is passed by the flue gases in the opposite direction as the region I. The third or coolest region is placed below the second region and is passed by the gases in the same direction as the first region. The tubes 22 exteriorly disposed at the sides of the first and the second region respectively are prolonged rearwardly as at 30 to extend adjacent to the circulation tubes 5, of the superheater chamber 24, thus forming cooled side walls for the chamber 20 for disassembling purposes. Corresponding to the amount of cooling and the decrease in the volume of the flue gases the cross sections or free passage for the gases are reduced from region to region with a view to keep the speed of the gases constant. Constructional reasons occasioned by the requisite distribution of weight may necessitate the omission of the tube elements in one of the regions so that the respective region will then serve as a conduit for the gases only. The regions are separated by horizontal separating slabs 30' overlying the longitudinal preheater tubes. The ends of the regions are interconnected by easily detachable connector plates 31, 31'. The exterior preheater tubes 22 adjacent the shell of the boiler are of larger diameter than the interior tubes 23 of bundles of tubes, so that the

tubes 22 contact each other longitudinally, thus preventing the hot gases from sweeping the shell of the preheater. The bundles of water tubes of the individual regions are interconnected by detachable bend connectors 32 so as to provide a continuous conduit for the feed water to pass through in counter flow to the flue gases. Alternatively, the regions of the preheater may be so arranged that the hottest region is situated at the bottom and the coolest region at the top as schematically represented in Fig. 7, or the second and third regions may each be divided in two ducts connected in parallel and disposed in symmetrical disposition above and below the first and hottest region I respectively (Fig. 8), the said parallel connected ducts being passed by the flue gases in the same direction. In Fig. 9 a modification of Fig. 8 is shown which is obtained by turning the arrangement shown in Fig. 8 through an angle of 90°, so that the separating slabs for the regions lie in vertical longitudinal planes of the locomotive. The cinders accumulating in the combustion chamber and the chamber for disassembling the superheater may be educted through special funnels 33 lined with masonry.

The part of the boiler constituted by the various drums i. e. the part which serves for evaporating inclusive of the superheater and the flue gas heated feed water preheater are separately mounted on the longitudinal frame of the locomotive. The forward end portion of the boiler is formed in usual manner by a smoke box from which the flue gases are discharged into the open by means of a blast nozzle appliance 34 or a ventilator respectively. At 35 an exhaust steam feed water heater is shown from which the water passes preheated to a temperature of from 80 to 100° C. to the region III of the flue gas heated feed water preheater, through a connecting pipe 39. The other end of the preheater 21 communicates with the drums 1, 1' by way of the pipe 40.

The water is admitted to the exhaust steam feed water heater 35 by means of a pipe 41 and an injector 41' which draws it from the tender (not shown) in a known manner.

I claim:

1. In a high pressure boiler for locomotives, in combination, a fire box having a fire bridge, the rear portion of said fire box behind said fire bridge constituting a combustion chamber, water tubes forming the side walls and ceiling of said fire box, at least one upper steam collecting drum communicating with said water tubes and protected by the same from being heated by said fire box, a superheater for the steam accumulated in said upper drum communicating with the latter, lower water drums communicating with said water tubes, forward and rearward water headers communicating with said upper and lower drums for providing circulation of the water, branch tube elements arranged between said upper and lower drums, water circulation tubes communicating with said upper and said lower drums, and a flue gas heated feed water preheater being subdivided into a number of sections arranged to heat the feed water in a counter flow to the flue gases connected with said upper drum, the whole arrangement being such that the total heating surface of said fire box inclusive of that of said combustion chamber in relation to the total heating surface in contact with the water of the boiler is about 1:7.

2. In a high pressure boiler for locomotives in

combination, a fire box having a fire bridge, the rear portion of said fire box behind said fire bridge constituting a combustion chamber, water tubes forming the side walls and ceiling of said fire box, at least one upper steam collecting drum communicating with said water tubes and protected by the same from being heated by said fire box, a superheater for the steam accumulated in said upper drum communicating with the latter, a forward extension on said upper steam collecting drum projecting at least to the front end of said superheater, a superheating chamber for accommodating said superheater and positioned underneath said forward extension of said upper steam collecting drum, lower water drums communicating with said water tubes, forward and rearward water headers communicating with said upper and lower drums, for providing circulation of the water, branch tube elements arranged between said upper and lower drums, and a flue gas heated feed water preheater being subdivided into a number of sections arranged to heat the feed water in a counter flow of the flue gases connected with said upper drum, the whole arrangement being such that the sum of the heating surface of said fire box inclusive of that of said combustion chamber in relation to the total heating surface in contact with the water of the boiler is about 1:7.

3. In a high pressure boiler for locomotives, in combination, a fire box having a fire bridge, the rear portion of said fire box behind said fire bridge constituting a combustion chamber, water tubes forming the side walls and ceiling of said fire box, at least one upper steam collecting drum communicating with said water tubes and protected by the same from being heated by said fire box, a superheater for the steam accumulated in said upper drum communicating with the latter, a disassembling chamber situated forwardly of said superheater and adapted to receive said superheater temporarily, lower water drums communicating with said water tubes, forward and rearward water headers communicating with said upper and lower drums for providing circulation of the water, branch tube elements arranged between said upper and lower drums, water circulation tubes communicating with said upper and lower drums, a flue gas heated feed water preheater connected with said upper drum, longitudinal exterior and interior water tubes in said preheater, the exterior tubes having a larger diameter than the interior tubes and contacting each other longitudinally, rearward extensions of said longitudinal water tubes of said preheater providing side walls for said disassembling chamber, separating baffles arranged between said water tubes inside said preheater, and succeeding horizontal heating sections provided by said separating baffles and having a cross-section adapted to conduct the escaping gases in a counter flow to

the feed water at substantially uniform speed, the whole arrangement being such that the total heating surface of said fire box inclusive of that of said combustion chamber in relation to the total heating surface in contact with the water of the boiler is about 1:7.

4. In a high pressure boiler for locomotives, in combination, a fire box having a fire bridge, the rear portion of said fire box behind said fire bridge constituting a combustion chamber, water tubes forming the side walls and ceiling of said fire box, at least one upper steam collecting drum communicating with said water tubes and protected by the same from being heated by said fire box, lower water drums communicating with said water tubes, forward and rearward water headers communicating with said upper and lower drums for providing circulation of the water, branch tube elements arranged between said upper and lower drums, a superheater for the steam accumulated in said upper drum communicating with the latter and disposed forwardly of said branch tube elements to be protected by the same, and a flue gas heated feed water preheater arranged forwardly on the locomotive and connected with said upper drum, the whole arrangement being such that the total heating surface of said fire box inclusive of that of said combustion chamber in relation to the total heating surface in contact with the water of the boiler is about 1:7.

5. In a high pressure boiler for locomotives, in combination, a fire box having a fire bridge, the rear portion of said fire box behind said fire bridge constituting a combustion chamber, water tubes forming the side walls and ceiling of said fire box, at least one upper steam collecting drum communicating with said water tubes and protected by the same from being heated by said fire box, lower water drums communicating with said water tubes, forward and rearward water headers communicating with said upper and lower drums for providing circulation of the water, branch tube elements arranged between said upper and lower drums, a superheater for the steam accumulated in said upper drum communicating with the latter and disposed forwardly of said branch tube elements to be protected by the same, a disassembling chamber situated forwardly of said superheater and opening to said superheater to receive the same temporarily while being taken out of position of use, and a flue gas heated feed water preheater being subdivided into a number of sections arranged to heat the feed water in a counter flow to the flue gases connected with said upper drum, the whole arrangement being such that the total heating surface of said fire box inclusive of that of said combustion chamber in relation to the total heating surface in contact with the water of the boiler is about 1:7.

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