

Aug. 7, 1934.

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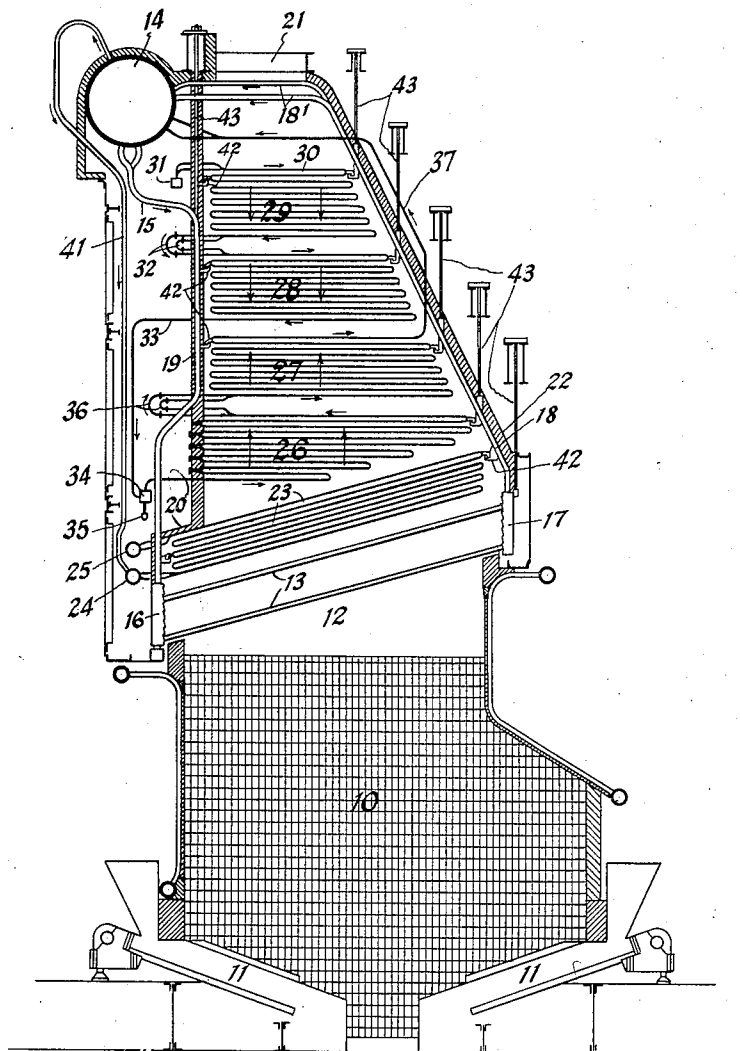
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STEAM BOILER

Filed April 13, 1932

2 Sheets-Sheet 1

Fig. 1



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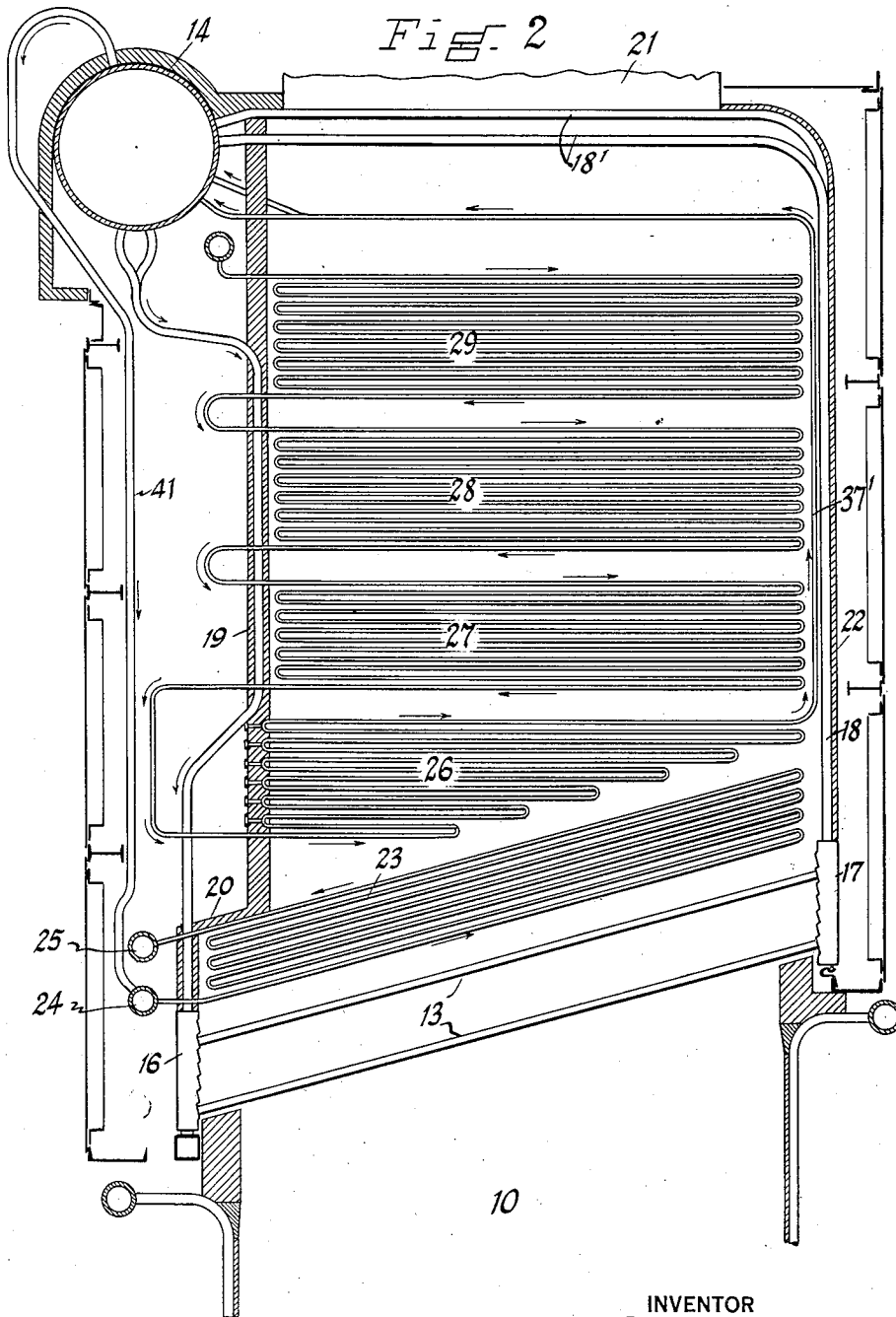
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STEAM BOILER

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Application April 13, 1932, Serial No. 604,977

7 Claims. (Cl. 122—299)

My present invention relates in general to water tube steam boilers, and more particularly to the construction and operation of water tube steam boilers which are characterized by the location of a steam and water separating drum or drums at a distance above the highest point of steam generation in a bank of natural circulation steam generating elements which is great as compared to the vertical distance between the highest and lowest points of steam generation in that bank.

The general object of my invention is the provision of a water tube boiler having an improved construction and arrangement of the fluid heating surface thereof. A more specific object of my invention is the provision of a high drum two-stage water tube boiler with an improved arrangement and proportioning of the fluid conduit elements constituting the forced circulation steam generating stage.

The various features of novelty which characterize my 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 I have illustrated and described preferred embodiments of my invention.

Of the drawings, Fig. 1 is a sectional elevation, partly diagrammatic, of a water tube boiler constructed in accordance with my invention; and Fig. 2 is a sectional elevation of a portion of the boiler shown in Fig. 1, illustrating a modified arrangement of the heating surface.

The embodiment of the invention illustrated in Fig. 1 consists of a water tube boiler unit having a fluid cooled furnace 10 of substantial fuel burning capacity and into which fuel is introduced and burned by a pair of oppositely positioned underfeed stokers 11. The upper end of the furnace chamber is substantially in alignment with the lower end of a vertical heating gas pass 12. A relatively shallow bank of natural circulation steam generating tubular elements 13 is positioned across the lower end of the gas pass 12. The tubes 13 receive preheated water from a transversely extending steam and water drum 14 located at a vertical distance above the highest point of steam generation in the tube bank 13 which is great as compared to the vertical distance between the highest and lowest points of steam generation in the tube bank. Downtake circulators 15 connect the bottom of the drum

14 to downtake headers 16 at the lower ends of the tubes 13. The steam generated in the tubes 13 passes through uptake headers 17 and uptake circulators 18 to the drum 14.

As shown in Fig. 1 the downtake circulators are bent laterally to define a portion of the gas pass. A vertical wall 19, having a lower offset portion 20, extends vertically from the downtake headers 16 to a heating gas outlet 21 at the upper end of the gas pass. The wall 19 includes and is supported by the wall defining portions of the downtake circulators. The opposite wall 22 of the gas pass extends upwardly from the uptake headers 17 at an inclination towards the wall 19 until the gas outlet 21 is reached. The uptake circulators 18 line the wall substantially throughout its extent, and have horizontal portions 18' extending across the tapering gas pass directly below the gas outlet 21.

It will be noted that in the above described construction only a small portion of the gas pass is occupied by fluid heating surface. The remaining portion of the gas pass is advantageously utilized for a compact and thermally efficient arrangement therein of a convection heated superheater and a steaming economizer. The superheater consists of a series of return bend tubes 23 arranged in parallel vertical planes, and providing parallel flow paths between the superheater inlet header 24 and outlet header 25. The legs of the tubes 23 are preferably arranged parallel to the tube bank 13 and between the wall portion 20 and the tube bank.

Substantially all of the remaining portion of the gas pass 12 is occupied by the steaming economizer, which, as shown, is divided into four superposed tube sections 26, 27, 28 and 29, each of which is formed by a horizontal series of return bend tubes 30 arranged in parallel vertical planes and providing parallel flow paths through the section. Each tube of the economizer sections is formed in a plurality of horizontal tube legs connected by vertical return bends. It will be noted that the available space is fully utilized by proportioning the lengths of the tube legs to the horizontal extent of the available space. For example, in the economizer section 26, the lowermost tube leg is quite short, while the remaining tube legs progressively increase in length in accordance with the varying horizontal distance between the wall 19 and the uppermost row of superheater tubes 23. The tubes of the economizer sections 27, 28 and 29 in the tapering portion of the gas pass have tube legs progressively decreasing in length upwardly.

The economizer sections form part of a forced circulation steam generating stage of the boiler. Feed water is delivered under pressure to the tubes of the economizer section 29 through a header 31 by means of a suitable boiler feed pump (not shown) and passes through the parallel flow paths formed by the tubes 30 into corresponding tubes in the economizer section 28. Flow resistor elements may be incorporated, if desirable, at the inlet portions of economizer tubes in the bank 29. Each pair of corresponding tubes is connected by a detachable return bend member 32 located externally of the gas pass wall 19. The return bend connections of adjacent tubes are preferably nested as indicated in Fig. 1. A downflow of water takes place in the economizer sections 29 and 28, and the heating surface of these sections is so proportioned that under all normal conditions of operation the feed water temperature will not be raised to the corresponding saturated steam temperature before leaving these sections.

The lowermost tube legs in the economizer section 28 pass through the wall 19 and are connected by circulators 33 to the lowermost legs of the tubes in the section 26. In the construction shown, a horizontal header 34 to which a valved drain connection 35 is applied, is interposed between the circulators 33 and the section 26. The header 34 serves also to mix the streams of heated water from the sections 29 and 28 before their delivery to the economizer section 26, which is exposed to the heating gases immediately after they have passed over the superheater tubes. The heated water passes upwardly from the header 34 through the economizer sections 26 and 27 through parallel flow paths, corresponding tubes in sections 26 and 27 being connected by external return bends 36. The water flowing through the tubes of the section 26 is rapidly heated to the saturated steam temperature and at some point therein steam is generated, the point of steam generation in each tube being substantially the same due to the interposition of the mixing header 34. The point of steam generation in all of the tubes of the lower economizer sections will vary with different conditions of operation. The heating surface in the several economizer sections is desirably so proportioned relative to the heat transfer surface in said natural circulation bank and the heat output of the furnace chamber that no steam will be generated until after the lower legs of the tubes in the section 26 have been passed. The discharge ends of the tubes in the economizer section 27 are connected to the drum 14 by uptake and downtake circulators 37, which extend along the outer side of the inclined portion of the wall 22, and then horizontally across the gas pass into the side of the drum 14. Steam separated in the drum 14 passes from the drum through steam circulators 41 to the superheater inlet header 24.

The superheater and economizer sections are preferably supported from the uptake and downtake circulators 15 and 18 by means of cooperating lugs 42 welded on the tube return bend portions and circulators 15 and 18. The circulators in turn are carried by hangers 43 depending from the steel framework surrounding the upper sections of the boiler and welded to the circulators 15 and 18, as indicated.

In operation, the heating gases generated in the furnace chamber 10 pass successively over the natural circulation tube bank, superheater, economizer sections and the horizontal portions

of the circulators 37 and 18 to the gas outlet 21. The described arrangement of the fluid heating surface in the gas pass presents a substantially maximum amount of heating surface to the heating gases flowing through the gas pass. The absence of flow baffles in the single vertical pass avoids the presence of dead gas zones and requires only a relatively small amount of fan power because of the low draft loss present in the boiler. The rate of heat transfer in all portions of the gas pass is maintained high by the increased mass flow per unit area of heating surface in the cooler portions of the pass provided by the tapered formation of the gas pass walls in that section.

It has been found that a countercurrent arrangement of water heating surface provides a high thermal efficiency. In constructions however intended to carry varying boiler loads, a wholly countercurrent circulation of water through the economizer sections would be disadvantageous, since whenever the supply of feed water to the unit was decreased substantially, the steam generated in the lower sections of the economizer would tend to rise through the downflowing water and oppose the downflow of water through those sections. If the water flow should become sufficiently low, steam would actually rise and cause the tubes in the lower economizer sections to become steam bound, and probably subsequent overheating of the tubes and water hammer troubles.

In the present construction substantially all of the economizer heating surface used for heating water is arranged for a countercurrent downflow of water therein, which is most efficient from a heat transfer standpoint, while the portions in which the steam is generated are arranged for an upflow of fluid therein parallel to the heating gas flow. With this flow arrangement all of the steam generated may freely pass upwardly to the drum 14 without affecting the water flow through the economizer. The heat transfer surface in the tube bank 13, superheater 23, and economizer are proportioned relative to one another and to the heat output of the furnace chamber to insure that the heating gases contacting with the economizer will be of such quantity and temperature that no water will be evaporated in the economizer prior to entering the economizer section 26. The very slight loss in thermal efficiency due to this arrangement is more than off-set by the practical circulation advantages attained by its use.

In the modification illustrated in Fig. 2, the pass is non-tapering and the tube legs on the banks 27, 28 and 29 are all of the same length and extend the full width of the pass. In this arrangement, the economizer section 27 and the lower portion of the section 26 form a part of the water heating surface of the forced circulation stage, and all of the steam generation in this stage will occur in the upper portion of the section 26. The use of special return bends 32 and 36 is avoided by an integral formation of corresponding tubes in the several sections. Furthermore, the junction header 34 between the downflow and upflow sections is also eliminated. The uptake circulators 37' connecting the section 26 with the drum 14 are arranged within the heating gas pass rather than externally thereof, as in Fig. 1. The modification shown in Fig. 2 is otherwise similar in construction and mode of operation to the construction shown in Fig. 1.

While in accordance with the provisions of the

statutes I have illustrated and described herein the best form of my invention now known to me, 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 my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

10 I claim:

1. A water tube boiler comprising a furnace chamber, a vertical heating gas pass in communication with said furnace chamber, a natural circulation bank of steam generating tubes positioned in the lower portion of said gas pass, a steam and water drum positioned above said bank, uptake and downtake circulators connecting said tube bank and drum, a forced flow economizer having a fluid flow therein independent of the fluid flow in said natural circulation tube bank and comprising a plurality of superposed economizer sections, each formed by a series of return bend tubes arranged in parallel and having parallel tube leg portions extending horizontally across said gas pass in the portion thereof bounded by said natural circulation tube bank, uptake and downtake circulators and drum, means interconnecting said economizer sections and providing a downflow through a section in the upper portion of said gas pass and an upflow through a section in the lower portion of said gas pass, and a conduit connecting said last mentioned section to said drum.

2. A water tube boiler comprising a furnace chamber, a vertical heating gas pass in communication with said furnace chamber, a natural circulation bank of steam generating tubes positioned in the lower portion of said gas pass, a steam and water drum positioned a substantial distance above said bank, uptake and downtake circulators connecting said tube bank and drum, and a forced flow steam generating stage having a fluid flow therein independent of the fluid flow in said natural circulation tube bank and comprising a plurality of superposed water heating and steam generating sections, each formed by a series of return bend tubes arranged in parallel and having parallel tube leg portions extending horizontally across said gas pass in the portion thereof bounded by said natural circulation tube bank, uptake and downtake circulators and drum, means interconnecting said sections and providing a downflow through water heating sections in the upper portion of said gas pass and an upflow through a steam generating section in a lower portion of said gas pass, and a conduit connecting said steam generating section to said drum.

3. A water tube boiler comprising a furnace chamber, a vertical heating gas pass in communication with said furnace chamber, a natural circulation steam generating stage comprising a bank of horizontally inclined tubes extending across said gas pass, a steam and water drum located a substantial distance above said tube bank, uptake and downtake circulators connecting said tube bank and drum, a plurality of superposed economizer sections arranged in said gas pass in the portion thereof bounded by said tube bank, uptake and downtake circulators and drum, each of said economizer sections being formed by a series of return bend tubes arranged in parallel and having tube legs extending horizontally across said gas pass, means interconnecting said economizer sections for a serial flow therethrough, and the tubes in the economizer

section nearest said tube bank having tube legs progressively increasing in length upwardly.

4. A water tube boiler comprising a furnace chamber, a vertical heating gas pass in communication with said furnace chamber, a natural circulation steam generating stage comprising a bank of horizontally inclined tubes extending across said gas pass, a steam and water drum located a substantial distance above said tube bank, uptake and downtake circulators connecting said tube bank and drum, a convection heated superheater comprising steam tubes in said gas pass above and extending parallel to said tube bank, a plurality of superposed economizer sections arranged in said gas pass in the portion thereof bounded by said superheater tubes, uptake and downtake circulators and drum, each of said economizer sections being formed by a series of return bend tubes arranged in parallel and having tube legs extending horizontally across said gas pass, means interconnecting said economizer sections for a serial flow therethrough, the economizer section nearest said superheater having tube legs at one side of and below the level of the upper ends of the uppermost superheater tubes and progressively increasing in length upwardly.

5. A water tube boiler comprising a furnace chamber, a vertical heating gas pass having a tapered upper section and in communication with said furnace chamber, a natural circulation steam generating stage comprising a bank of horizontally inclined tubes extending across said gas pass, a steam and water drum located a substantial distance above said tube bank, uptake and downtake circulators connecting said tube bank and drum, and a forced flow steam generating stage having a fluid flow therein independent of the fluid flow in said natural circulation tube bank and comprising superposed economizer sections arranged in said gas pass in the portion thereof bounded by said tube bank, uptake and downtake circulators and drum, each of said economizer sections being formed by a series of return bend tubes arranged in parallel and having tube legs extending horizontally across said gas pass, means interconnecting said economizer sections for a serial flow therethrough, the economizer section nearest said tube bank having tube legs progressively increasing in length upwardly, and the economizer section in the tapered portion of said gas pass having tube legs progressively decreasing in length upwardly.

6. A water tube boiler comprising a furnace chamber, a vertical heating gas pass having a tapered upper section and in communication with said furnace chamber, a natural circulation steam generating stage comprising a bank of horizontally inclined tubes extending across said gas pass, a steam and water drum located a substantial distance above said tube bank, uptake and downtake circulators connecting said tube bank and drum, a convection heated superheater comprising steam tubes in said gas pass above and extending parallel to said tube bank, and a forced flow steam generating stage comprising superposed economizer sections arranged in said gas pass in the portion thereof bounded by said superheater tubes, uptake and downtake circulators and drum, each of said economizer sections being formed by a series of return bend tubes arranged in parallel and having tube legs extending horizontally across said gas pass, means interconnecting said economizer sections and providing a downflow in a section in the tapered portion of said gas pass and an upflow in the section

nearest said superheater, the economizer section nearest said superheater having tube legs at one side of and below the level of the upper ends of the uppermost superheater tubes and progressively increasing in length upwardly, and the economizer section in the tapered portion of said gas pass having tube legs progressively decreasing in length upwardly.

7. In a steam boiler comprising a furnace chamber, a vertical heating gas pass arranged for an upward flow of heating gases therethrough from said furnace chamber, and a steam and water drum, a steaming economizer having an upper water heating section and a lower steaming section superimposed in said gas pass, each of said sections having a multiplicity of vertically

spaced tubes connected in series and forming continuous predetermined flow paths insuring progressive fluid heating from the inlet thereto to the discharge therefrom, means for supplying feed water under pressure to the inlet end of the uppermost tubes of said water heating section, conduit means comprising a water mixing header connecting the discharge end of the lowermost tubes in said water heating section to the inlet end of the lowermost tubes of said steaming section, and means for conducting the fluid discharge from the discharge end of the uppermost tubes in said steaming section directly to said steam and water drum.

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