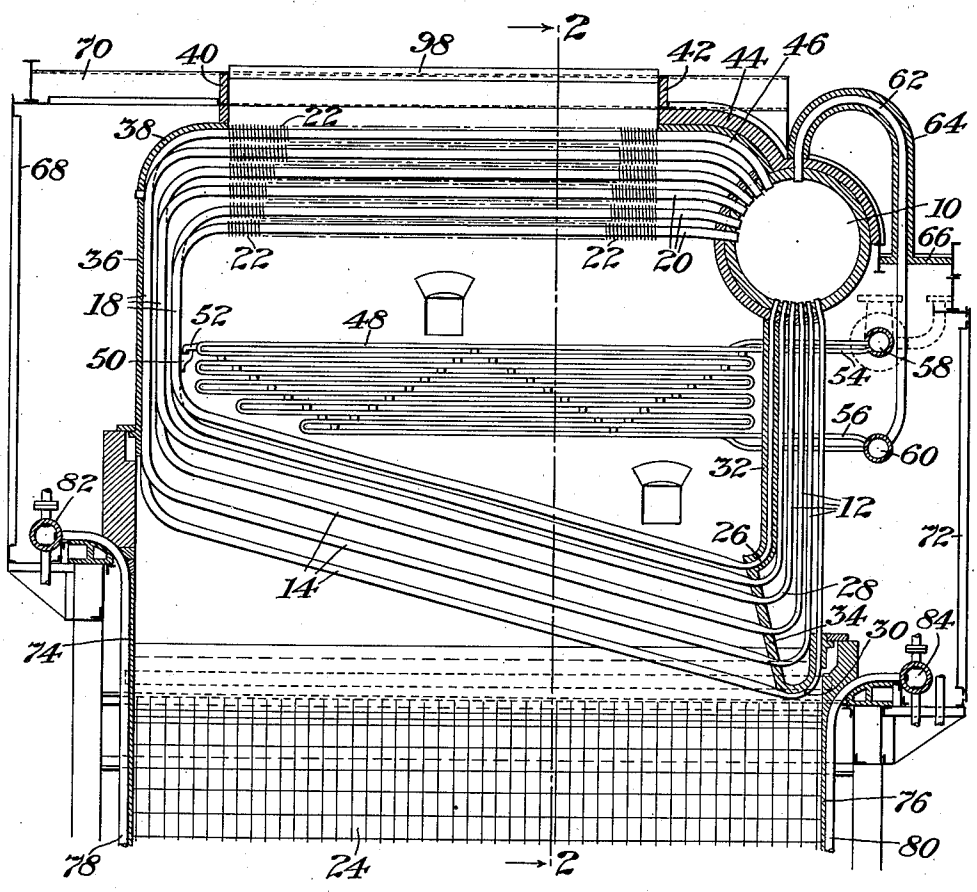
March 30, 1937. I. HARTER 2,075,609

STEAM BOILER

Original Filed Nov. 21, 1930 2 Sheets-Sheet 1

Fig. 1




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Fig. 2

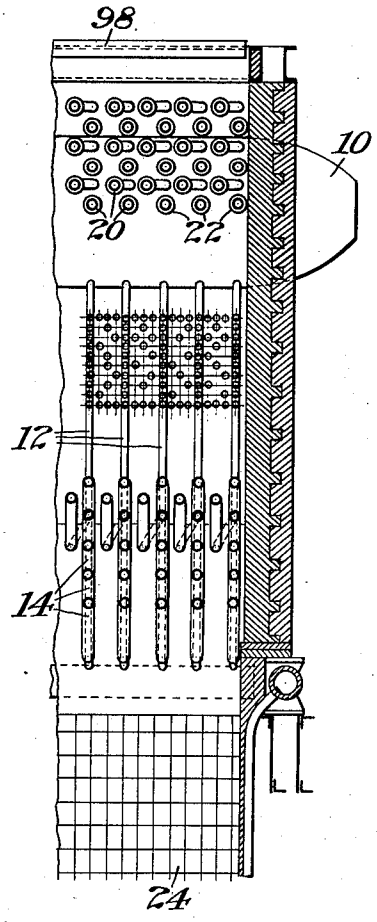



Fig. 3

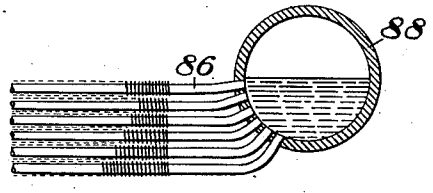
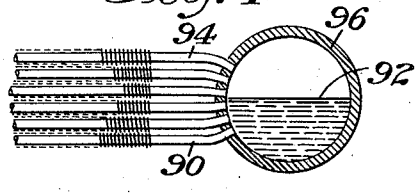



Fig. 4




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# UNITED STATES PATENT OFFICE

2,075,609

## STEAM BOILER

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Application November 21, 1930, Serial No. 497,109
Renewed December 14, 1934

17 Claims. (Cl. 122—331)

Steam engineering denotes the art with which this invention is concerned. More particularly, it relates to steam generation.

An object of the invention is to improve the utilization of furnace heat in the production of steam in a boiler of the water tube type for high pressure steam generation.

Another object of the invention is to eliminate disadvantages incident to the existence of "cold spots", or positions in boilers where the furnace gas is comparatively ineffective.

Other objects are the minimizing of heat losses attributable to the baffles in known water tube boiler constructions and the elimination of losses due to furnace gas turns in the same structures.

It is also an object of the invention to provide a headerless single pass water tube steam boiler having no baffles and presenting the other characteristics above indicated.

A further object of the invention is to materially reduce the cost of construction and operation of very high pressure boilers of the class indicated. At the same time, the invention contemplates such a boiler having a high efficiency in heat exchange because of the absence of more than one gas pass.

Still another object of the invention is to provide a method of manufacturing boilers having no headers.

Other objects of the invention will appear as the accompanying description proceeds.

The description has reference to the accompanying drawings, in which:

Fig. 1 indicates a vertical sectional view of a natural circulation boiler having a plurality of entirely independent steam and water circuits leading to and from a single common steam and water drum.

Fig. 2 is a partial transverse vertical section taken on the line 2—2 of Fig. 1 .

Figs. 3 and 4 are detail views indicating alternate ways for connecting the tubes to the steam and water drum, all below the water line in Fig. 3; some below the water level, and some above in Fig. 4.

The natural circulation boiler shown in Fig. 1 includes a single steam and water drum 10 provided with independent steam and water circuits. These circuits include downcomers 12 leading the water from the drum 10. Horizontally inclined sections 14 lead from the downcomers 12 to steam and water risers 18. The circulations in the independent circuits are completed through upper sections 20, having fin tubes 22. Forming the risers, downcomers, and connecting sections as one continuous pipe by welding and then bending the pipe to form the component boiler parts facilitates manufacture in the shop and erection in the field. Compactness of the installation is also promoted, smaller diameter risers being thus joined to adjoining connecting sections by gradually tapering bends.

In the illustrative installation there is provided a single transverse gas flow from the furnace 24 past the tube bank 14 and through the flue 26.

In the illustrative apparatus the bends 26, 28 and 30 unite the downcomers with the adjacent sections 14. The welding of relatively small bore downcomers to tube sections of larger bore provides straight tubes with intermediate sections of gradually tapering bore. The bending of these straight unitary tubes at such sections produces the junctures or bends and component boiler parts illustrated.

Protection of the downcomers and the bends 26 and 28 against excessive heat, and the elimination of opportunities for short circuiting of furnace gases are accomplished by the wall or baffle 32 having an extension 34 leading between and closely fitting around the connecting tubes 14. The bottom part of this wall follows the bend of the juncture of the outermost riser and the lower tube of the lower section 14 and extends to the furnace wall.

Along the external row of risers 18 is an upright wall 36 above which the boiler is enclosed by the extension 38 abutting the vertical flue wall 40. Similar flue walls including the side 42 define the flue 98 leading from the convection heat transfer zone in which the sections 20 are located. The furnace enclosure is completed by a drum wall 44 preferably following the curve of the uppermost tube 46.

Economy in the number of water tubes 20 in the upper connecting bank is promoted by the use of finned sections of tubes. A small number of such finned sections will absorb more heat than a larger number of plain tubes, and will cost less. Compactness of the installation is also promoted by the use of such finned sections of tubes.

The mode of manufacture whereby multiple diameter straight tubes are bent into component boiler parts before they are expanded at their ends into a boiler drum permits helical fins to be welded from a straight bar onto the tube sections in an automatic process.

When helical fins are used on the horizontal circulator sections 20 advantage may be taken

of an automatic manufacturing operation whereby such fins are formed from a heated steel bar wound around a straight tube section. Associated with this process automatic welding may simultaneously take place to weld the fins to the tubes. The illustrative method permits such fin manufacture when the entire tubular lengths (including sections 12, 14, 18 and 20) have fins formed thereon before they are bent to form the risers, downcomers, steam generators, and circulators. The entire tube lengths are bent and assembled so that corresponding fin sections form a bank of horizontal circulators.

The furnace gases in passing in one direction straight through the boiler are not only cooled by their contact with the tube sections 14, but they are also cooled by the heat transfer taking place as they pass through the superheater 48. The superheater illustrated is located above the tubes in the radiant heat zone.

At one end of the superheater is a fixed support 50 and a complementary extension 52. At its other end are connectors 54 and 56 leading respectively to the drums 58 and 60. Steam is admitted to the latter drum through the conduit 62 leading from the upper part of the drum 10 through insulation 64 and the boiler wall 66. The specific arrangement of elements (including the parts 50 and 52) whereby the superheater is supported and its tubes prevented from sagging forms no part of the present invention. It is shown and claimed in the co-pending applications 532,193 and 537,354 filed respectively on April 23, 1931 and May 14, 1931 to cover inventions made by Lambert Kooistra and Frank X. Gilg.

The boiler enclosure is completed by a front wall 68, top wall 70, back wall 72, and water tube furnace walls 74 and 76. The tubes 78 and 80 of the water walls lead respectively to upper headers 82 and 84. They are connected at the lower ends to similar headers not herein shown.

In Fig. 1 the tube sections 20 are connected into the upper part of the drum 10 thereby minimizing some separation difficulties, whereas in Fig. 3 the connections between the similar circulators 86 and the similar drum 88 are shown beneath the water level of the drum. Here, wetness of all of the tubes is ensured. Additional circulation head is a compensation for the back pressure effects of increased steam volume.

A third type of circulator and drum connections is shown in Fig. 4. Here, tubes 90 are connected with the drum below the water level 92 and other tubes 94 are connected with the drum 96 above the water level. Equalization of circulation heads is promoted by this arrangement.

By reason of the single gas pass, characteristic of the illustrative boiler, the expense of the original installation and subsequent repair and replacement of baffles is eliminated. Wall erosion due to the rapid movements of the furnace gas stream is minimized because the furnace gas is proceeding in a direction parallel to the furnace walls in contradistinction to the action in furnaces having two or more gas passes with gas currents moving directly against baffles. The present structure minimizes heat losses attributable to baffles. Resistance to draft is also minimized. The absence of turns in the gas stream, also, promotes the maximum of effectiveness in use of the draft.

The provision of tubes which are continuous from the water outlet of the drum to the steam and water inlet eliminates heat losses which, in other constructions, have existed because of the cumbersome connections between such parts of the boiler as the downcomers and the steam generating sections. In the present structure there are no such joints or connections to be uselessly heated.

When the boiler shown in Fig. 1 of the drawings is modified for gas flow generally horizontally of the boiler and transversely of the steam generating bank of tubes the whole organization may be considered as rotated about 90 degrees from the position shown. Then the tube sections 20 may be the boiler downcomers.

The elimination of headers or lower drums is an important feature of the invention disclosed. There is thus eliminated not only the cost of the material which goes into such additional parts, but also the labor cost in manufacturing such drums and headers, testing them, and assembling them with relation to the various tubes which are represented by the tube sections in the instant application.

While this invention has been described with reference to the particular structure indicated in the accompanying drawings it is not limited thereto but is of a scope commensurate with the scope of the subjoined claims.

What I claim is—

1. A water tube steam boiler comprising, in combination, a single drum, a plurality of independent circulation circuits leading to and from the drum, a single continuous tube constituting each independent circulation circuit and expanded into the common drum at both ends, corresponding parts of the tubes comprising a downcomer section located beneath the drum, means for shielding the downcomer section from contact with furnace gases, a group of corresponding parts of the tubes constituting a riser section remote from the downcomer section and delineating with the downcomer section a single upright gas pass, a second group of corresponding parts of the tubes constituting a low level tube bank connecting the riser into the downcomer sections, and a high level tube bank composed of corresponding parts of the tubes continuing the circulation from the upper part of the riser section whereby the furnace gases must pass the high level tube bank and the lower level tube bank in series.

2. A water tube steam boiler having a plurality of independent circulation circuits each of which is made up of a single tube expanded at both ends into the drum, corresponding upright parts of the tubes comprising downcomers and being located underneath the drum, a group of corresponding parts of the tubes constituting a riser section remote from the drum, a low level bank of corresponding parts of the tubes connecting the riser section and the downcomer section, and a high level bank of tubes connecting the riser sections and continuing the circulation from the riser sections, both of said banks of tubes comprising straight and parallel tube sections extending from side to side of a gas pass.

3. In a headerless water tube boiler having a steam and water drum, a plurality of integral separate tubular loops each of which is bent to form water downcomers, risers, circulators, and steam generating sections; the combination therewith of a furnace delivering its gases in a single upright pass extending across the steam generating sections and then the circulators, and a furnace wall positioned in front of the down-

comers and preventing the furnace gases from contacting therewith in a gas pass.

4. The combination as expressed in claim 2 characterized by the fact that the tubes of the high level bank extend horizontally to constitute horizontal circulators and have helical fins extending circumferentially with respect thereto.

5. A water tube steam boiler having a plurality of independent circulation circuits each of which is made up of a single tube expanded at both ends into the drum, corresponding upright parts of the tubes comprising downcomers and being located below the drum, a group of corresponding parts of the tubes constituting a riser section remote from the downcomers, a low level bank of corresponding steam generating parts of the tubes connecting the riser section and the downcomers, tube sections connected to the riser sections and continuing the circulation from the riser sections, and a wall protecting the downcomers from impingement by heating gases moving in a gas pass across the steam generating parts.

6. A water tube steam boiler having a plurality of independent circulation circuits each of which is made up of a single tube expanded at both ends into the drum, corresponding upright parts of the tubes comprising downcomers and leading downwardly from the drum, a group of corresponding parts of the tubes constituting a riser section remote from the downcomers, a low level bank of corresponding steam generating parts of the tubes connecting the riser section and the downcomers, and a high level bank of tube sections continuing the circulation from the riser sections, both the high level and the low level banks of tubes comprising straight and parallel tube sections extending transversely of a gas pass; and wall means protecting the downcomers against impingement by heating gases moving in the gas pass.

7. In a boiler; a steam and water drum; and steam and water circulating tubes each expanded at both ends in the drum and running uninterruptedly from one position in the drum to a return position in the drum; the tubes running from the drum first downwardly through an upright bank of tube sections of small diameter and small drum spacing, thence upwardly and away from the upright bank through an inclined bank of tube sections which extend across the gas pass from a boiler furnace and are of greater diameter than the first tube sections, the tubes thence leading upwardly through the vertical bank of tubes to circulator tubes which complete the circuit and have a drum spacing greater than that of the downcomer sections.

8. A water tube steam boiler comprising a series of circulation tubes each of which is expanded into the same drum at both ends, corresponding sections of the tubes constituting a bank of steam generating sections located at a level lower than the level of the drum, other corresponding portions constituting a second tube bank at a higher level and exposed to furnace gases in the same gas pass as the first tube bank, other portions comprising downcomer sections and riser sections, and wall means interposed relative to the drum and the steam generating sections and positioned in front of the downcomers to prevent impingement on the downcomers by the furnace gases moving in the gas pass.

9. In a water tube steam boiler, a furnace, a boiler drum at one side of a gas pass from the furnace, independent boiler circulation circuits each comprising a single tube loop having an inlet and an outlet in communication with the drum, corresponding parts of the loops directly exposed to furnace gases, other corresponding sections of the loops constituting downcomers supplying water to said parts, and wall means positioned below the drum interposed relative to the downcomers and said parts to prevent impingement on the downcomers by furnace gases moving in the gas pass.

10. A water tube boiler comprising a single drum, a plurality of independent circulation circuits connected to the drum, each circuit comprising a single length of tubing expanded into the drum at both ends, corresponding sections of the tubes comprising a riser section, other adjacent corresponding parts of the tubes constituting circulation completing sections, downcomer sections having a diameter smaller than the other sections and metallic helical fins formed on the circulation completing sections so that they extend circumferentially thereon.

11. A water tube boiler comprising, in combination, a steam and water drum, a plurality of independent circulation circuits each consisting of a single tube expanded into the drum at both ends and each having horizontal circulator portions delivering steam and water into the drum entirely beneath the water level of the drum, the horizontal circulator portions having helical circumferential fins welded thereon.

12. A water tube boiler having a natural circulation to and from a drum and comprising, a steam and water drum, a plurality of parallel conduits having separate inlets communicating with the water space of the drum and separate outlets in the steam space of the drum, the conduits extending across the same gas pass in separated first and second tube banks in which the fluid flow is in opposite directions, the first bank exposed to higher gas temperatures and constituting a steam generating section spaced from the drum and connected thereto by parts of said conduits having a flow area smaller than that of the last mentioned bank, and the second tube bank exposed to lower gas temperatures having a higher ratio of external area to internal flow area.

13. A water tube steam boiler comprising a single drum, a plurality of independent circulation circuits connected to the drum, each circuit comprising a single length of tubing expanded into the drum at both ends, and corresponding sections of the tubes comprising a riser section and a downcomer section connected by a steam generating section, the downcomer section having a smaller flow area than the other sections and being shielded to eliminate contact therewith by gases moving in a gas pass.

14. In fluid heat exchange apparatus, a plurality of parallel conduits communicating with a fluid chamber and endeavoring to provide separate circuits of a fluid to be heated, said circuits extending across a heating gas flue at two spaced positions where the conduits form two separate banks of tubes between and over which heating gases pass, and a superheater arranged between said banks and including a bank of small diameter closely spaced tubes the parts of the conduits constituting the bank last contacted by the gases being provided with metallic extended surface elements and having a higher ratio of external area to internal flow area than the parts of the other bank, and the ratio of effective external surface of the superheater to its effective internal surface being greater than the corresponding

ratio for the bank of tubes first contacted by the furnace gases.

15. In a natural circulation steam boiler, a casing having front and rear walls, a steam and water separator, a steam generating section including inclined parallel tube sections extending across a gas pass, an uptake section at one side of the gas pass near one of said walls and including upright tube sections which are continuations of the tube sections of the generating section, one uptake section being connected to the separator both above and below its water line, a downtake section connecting the separator and the generating section and including a plurality of upright tube sections, said downtake section being located near the wall opposite the uptake wall and having a flow capacity less than that of the uptake section, and means for shielding the downtake tubes from contact with furnace gases.

16. In fluid heat exchange apparatus, a steam and water separator, inclined parallel tubes arranged in a plurality of horizontal rows and constituting a steam generating section communicating with the separator, a furnace from which hot gases sweep in a gas pass across the tubes, an upright riser section disposed at one side of the gas pass and including tube sections forming continuations of the generating tubes and arranged in a number of rows smaller than the number of horizontal rows in the generating section, and means connecting the riser section with the separator.

17. In a water tube steam boiler, a boiler setting, a furnace, a steam and water separator drum in the setting, a steam generating section including tube lengths inclined throughout their extent toward the uptake end of the setting, a superheater between the generating section and the drum, tubular riser parts constituting an upright tube bank at one side of the setting and made up of tube sections which are continuations of the separate tube lengths of the generating section, downcomers communicating with the separator and the steam generating section, and means connecting the separator and the riser parts.

ISAAC HARTER.