Nov. 5, 1940. L. KROTKOV 2,220,486

BOILER

Filed July 2, 1938 3 Sheets-Sheet 1

Fig. 1.

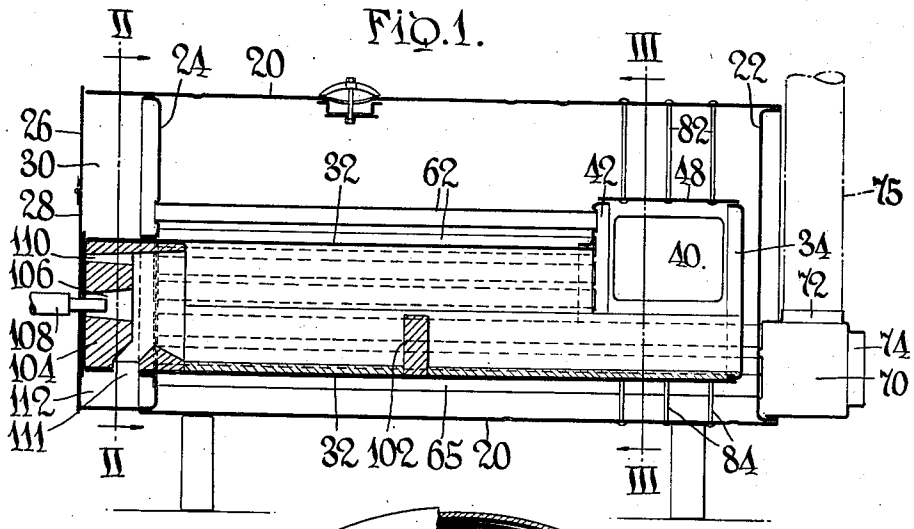
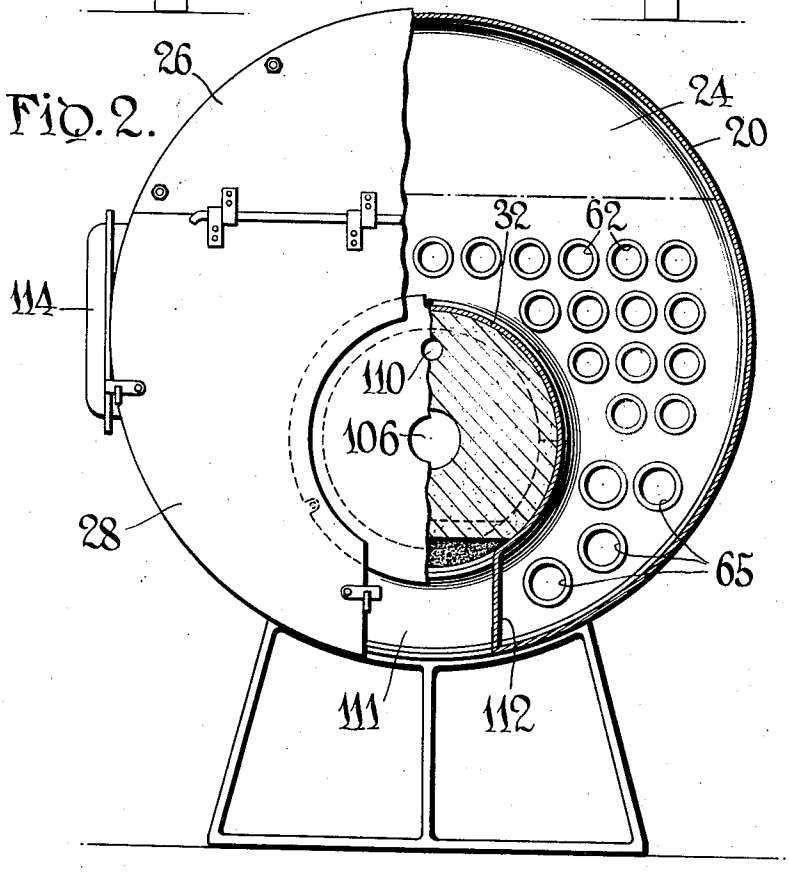


Fig. 2.



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BOILER

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Fig. 3.

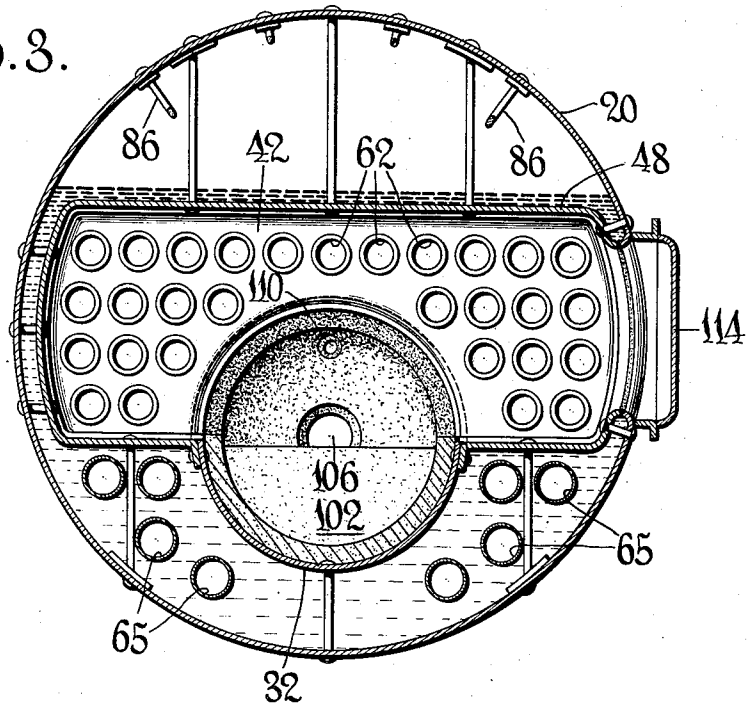
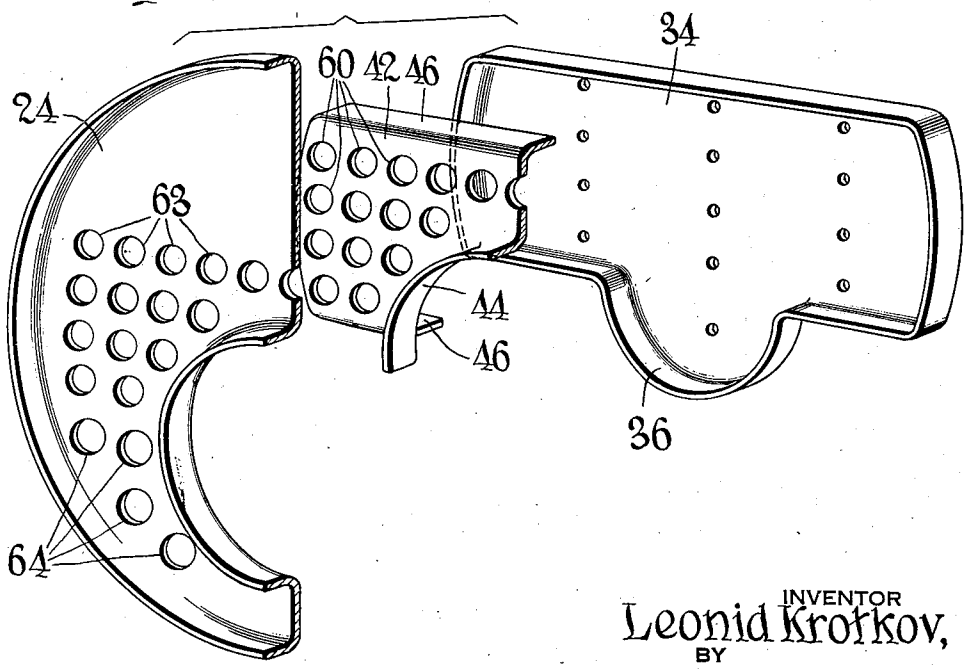


Fig. 4.



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Fig. 5.

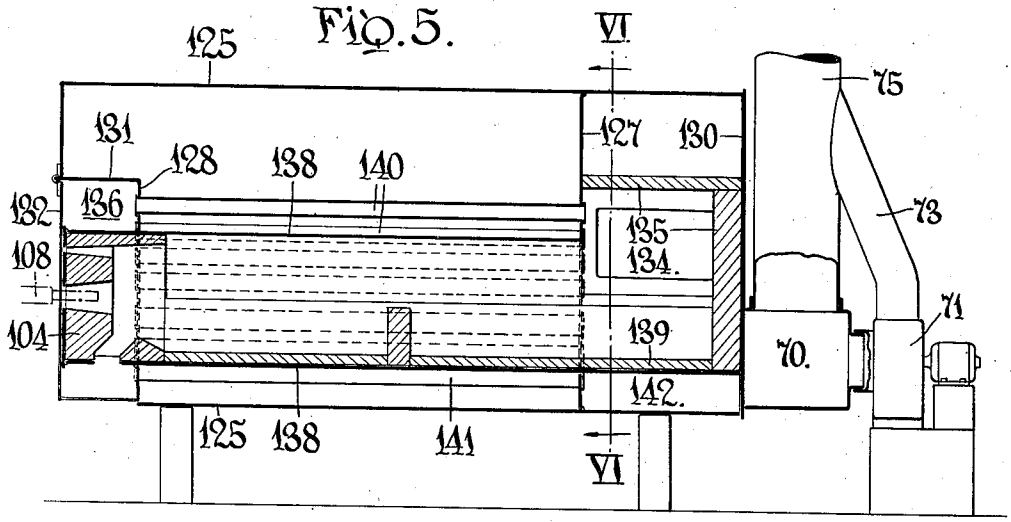
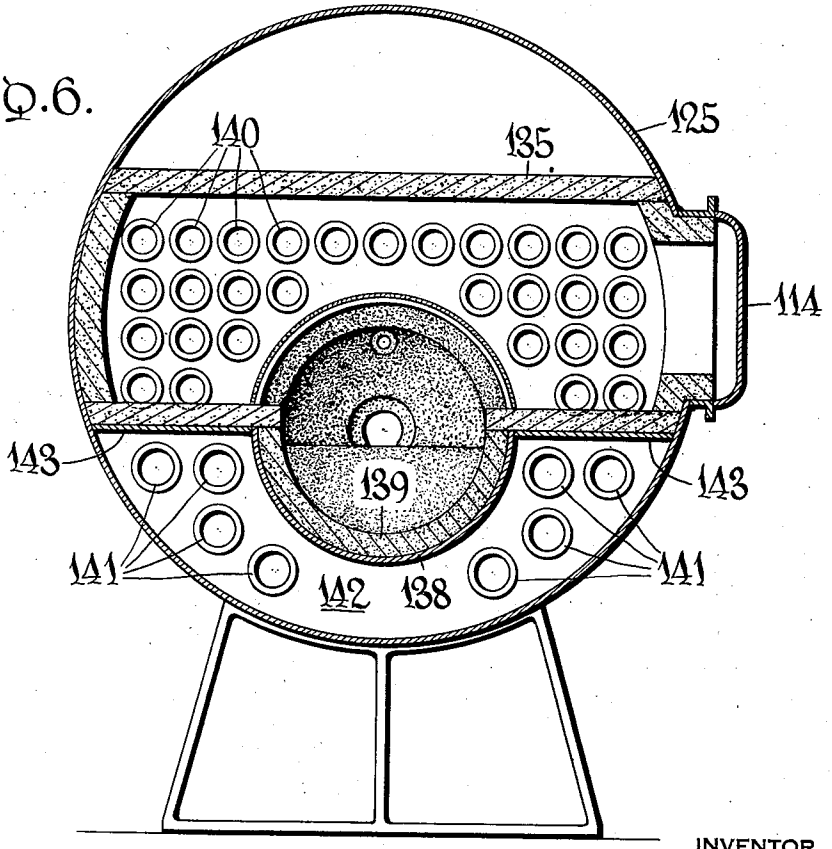


Fig. 6.



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Patented Nov. 5, 1940 2,220,486

UNITED STATES PATENT OFFICE

2,220,486

BOILER

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Application July 2, 1938, Serial No. 217,259

2 Claims. (Cl. 122—149)

This invention relates to hot water or steam boilers for either high or low pressure service, and has particular reference to fire tube boilers of the so-called Scotch marine type. It is known that various attempts have been made to provide multiple pass fire tube arrangements in Scotch marine type boilers with the object of obtaining maximum heat absorption, but such previous attempts have failed to obtain maximum thermal efficiency in combination with suitable water circulation, and have possessed certain disadvantages attending lack of simplicity and ruggedness of construction.

One object of the present invention is to provide an improved boiler of the Scotch marine type of increased thermal efficiency.

Another object of the present invention is to provide an improved boiler of the Scotch marine type combining compactness of arrangement and structural simplicity and ruggedness.

Another object is to provide a boiler of the type described and embodying the objects stated hereinabove which is relatively inexpensive to manufacture and accessible and easy to maintain in repair.

Other objects and advantages of the invention will appear from the claims and the specification hereinafter which is exemplary thereof.

The invention contemplates generally the provision in an improved manner of a boiler having some of the general characteristics of the well known Scotch marine type of boiler and incorporating certain novel features whereby increased thermal efficiency is obtained in conjunction with simplicity and ruggedness of structural design. These objects and advantages are obtained by providing a multiple pass fire tube arrangement in combination with an elongate form of fire box; the fire box and fire tubes all being enclosed within a tubular type casing and encompassed by the water contained therein. The fire box element is disposed within the lower intermediate portion of the casing in parallel and spaced relation to the lower wall portion of the casing and at a sufficient distance therefrom to provide for the disposition of a series of fire tubes therebetween for conveying the final flow of the gaseous products of fuel combustion through the coldest portion of the boiler water. Another series of fire tubes is disposed longitudinally of the boiler in parallel relation with respect to one another and to the fire box, the members thereof being arranged between the upper wall portion of the fire box and the casing and within the water level of the boiler, for conveying the fuel gases from the outlet end of the fire box at one end of the boiler toward an opposite end of the boiler through the hottest portion of the boiler water and thence into the first-mentioned series of tubes.

The fire box member provides for the first pass of fuel gas through the boiler water. The two series of tubes are preferably of special relative sectional dimension relation so as to provide for improved gas flow through the tube system; improved water circulation, and maximum heat transfer performance. The first series of tubes provides for thorough dispersement of the relatively hot fuel gas issuing from the outlet end of the fire box through the hottest portion of the boiler water by means of a series of fire tubes adapted to provide a practical maximum of heat transfer area. Subsequent to this, the fuel gases are directed downwardly at an end of the boiler and thence into the second series of return tubes constituting the third pass of the fuel gases through the boiler, the second series of tubes preferably comprising a lesser number of tubes which are of greater sectional dimensions as compared to the first series of tubes; whereby the relatively spent fuel gases are conveyed finally through the coldest portion of the boiler water in an improved manner before being discharged from the boiler. Stack or fan means are preferably employed in conjunction with the boiler to provide a positive draft through the fire box and tube system thereof. These general features, in combination with certain other novel and important features of construction hereinafter described, contribute to the provision of a boiler having many important advantages.

In the drawings:

Fig. 1 is a fragmentary diagrammatic longitudinal section through a boiler incorporating the principles of my invention;

Fig. 2 is a view, on an enlarged scale, partly in end elevation and partly in section along line II—II of Fig. 1;

Fig. 3 is a transverse section, on an enlarged scale, taken substantially along line III—III of Fig. 1;

Fig. 4 is a fragmentary perspective, on an enlarged scale, of the head members of the construction shown in Fig. 1;

Fig. 5 is a view similar to Fig. 1 of another form of boiler incorporating features of the invention; and

Fig. 6 is a transverse section, on an enlarged scale, taken substantially along line VI—VI of Fig. 5.

In the drawings, and referring now more particularly to Figs. 1 to 4, a boiler embodying my invention is shown as comprising essentially a tubular casing 20, a rear head 22, and a front head 24. The front head 24 is inset relative to the front end of the casing 20 which is closed by a cover plate 26 and door 28 to provide a gas conducting chamber 30 therebetween. A fire box for the boiler is provided in the form of an enlarged tube or shell 32 extending inwardly of the casing 20 from its front end rearwardly toward the rear head 22 and in spaced relation with respect to the casing 20. The furnace shell 32 terminates at a position adjacent the rear head 22 but in spaced relation therefrom in connection with a flanged combustion chamber head 34, the lower portion of which is provided with a marginal turned flange 36 adapted to conform to the lower rear terminal portion of the furnace shell 32 in lapped relation. The flange 36 and the shell 32 are connected in fluid tight relation in accord with any suitable form of connection construction, as by means of riveting, or by welding if desired; as will also be the case in connection with any of the joints between the structural elements of the boiler hereinabove described. The upper portion of the combustion chamber head 34 extends upwardly beyond the upper limits of the furnace shell 32 and laterally beyond each side thereof to provide a rear end closure element for an enlarged combustion chamber 40 which is in open communication with the rear end of the furnace shell 32, the bottom portion of the combustion chamber being defined by the lower rear end portion of the furnace shell 32. The combustion chamber head 34 is arranged in substantially parallel spaced relation with respect to the rear casing head 22 (Fig. 1) so as to provide a water space therebetween.

A front head or tube sheet 42 for the combustion chamber 40 is provided of a form which is similar in outline to the upper portion of the rear head 34, but differs therefrom (Fig. 4) in being provided with a flanged arcuate recessed portion as at 44 to receive the furnace shell 32 therein. The front tube sheet 42 is arranged in spaced and substantially parallel relation with respect to the rear head 34 and is provided with a turned marginal flange portion 46. In the region of the combustion chamber 40 the upper portion of the furnace shell 32 is cut away to provide for open communication between the furnace shell and the combustion chamber. The combustion chamber 40 is completed by the provision of a wrapper sheet 48 extending between the front and rear head members 42 and 34 respectively, and disposed about the flanged upper and side edge portions thereof; and at its lower terminal edges the wrapper sheet 48 connects to the furnace shell 32.

The tube sheet 42 of the combustion chamber 40 (Fig. 4) is provided with a series of openings 60 to receive the rear ends of a series of fire tubes 62 which extend longitudinally of the boiler in substantially parallel and spaced relation to the furnace shell 32 into supported connection of their opposite ends with the front head 24 as by insertion through openings 63 therein. The front head 24 is also provided with a lower series of openings 64 to receive the front ends of a second lower series of fire tubes 65 which extend longitudinally of the boiler in spaced and substantially parallel relation with respect to the furnace shell 32. The rear ends of the lower series of tubes 65 extend through and are connected in fluid tight relation to the rear casing head 22 in such manner as to be in open communicating relation with a gas collecting box 70 provided adjacent the rear end of the boiler. The gas box 70 may be provided with a pair of controllable discharge openings 72 and 74 for arranging for withdrawal of discharge gases from the boiler either by means of a natural draft stack 75 or a draft inducing fan (not shown), as may be desired.

The boiler construction is preferably braced by means of stay bolts, tie rods, diagonal braces and the like, as may be required in any given instance, taking into account the working pressures and heat stresses to be imposed thereon. For example, stay bolts 82 are preferably provided between the combustion chamber wrapper sheet 48 and the boiler casing 20; and stay bolts 84 are preferably provided between adjacent portions of the furnace shell 32 and the boiler casing 20. Thus, the combustion chamber 40 and the furnace shell 32 are substantially braced relative to the boiler casing. Diagonal braces 86 may be disposed between adjacent abutting portions of the casing 20 and the front and rear boiler heads 22 and 24 (Fig. 3).

A baffle member 102 of refractory or other suitable material may be disposed within the furnace as shown (Fig. 1) to provide turbulent flow of flame and hot gases therethrough for the purpose of insuring prompt fuel ignition, equalizing temperatures throughout the furnace, and increased combustion efficiency. The fore part of the furnace may be provided with any suitable type of insulating construction as may be required; and as shown herein is fitted with a refractory or fire brick lining 104 to insulate against heat transfer between the furnace and the gas in the hot gas chamber 30. A suitable opening 106 is provided in the lining 104 for accommodating a fuel nozzle 108; and other suitable openings 110 and 111 may be provided above and below the fuel jet, respectively, for the intake of secondary air for combustion.

The lower opening 111 may be provided intermediately of the front closure plate 28 and the front head 24 by cutting away a lower portion of the casing 20 therebetween and providing a pair of opposed partition plates 112 (Fig. 2) between the casing 20 and the fire box shell 32. An access or cleanout door 114 (Fig. 3) may be conveniently located at a side wall portion of the combustion chamber 40; and it will be understood that all other usual accessories as may be needed may be supplied in connection with the boiler in accord with usual principles of boiler construction.

It will be seen from examination of Fig. 4 that the rear combustion chamber head 34 is of simple and rugged design, flanged at its marginal edge, and suitable for formation from standard sheet or plate without difficulty or problems of manufacture. Likewise, it will be understood that this single head member serves a combination of purposes, constituting at once a wall portion of the combustion chamber 40 and a supporting means for the rear end of the fire box shell 32; but by reason of the reduced semi-circular lower portion thereof there is provided ample space for the disposition of the return tubes 65 thereabout and between adjacent lower portions of the fire box shell 32 and the casing 20.

The forward combustion chamber head 42 (Fig. 4) is also of simple and rugged design and of such configuration as to be manufactured with a minimum of operations and expense, and simul-

taneously provides supporting and anchoring means for the rear ends of the tubes 62 and supporting means for the upper rear end portion of the fire box shell 32. Also, it will be apparent that the wrapper sheet 48 and the heads 42 and 34, in combination with the cut away portion of fire box shell 32, comprise a particularly simple and effective construction for providing reversal of direction of gas flow through the fire box and the tubes 62.

The front head 24 is also of extreme simplicity and ruggedness of design, and is also capable of manufacture through the employment of a minimum number of relatively inexpensive manufacturing operations, and simultaneously functions to relatively support the fire box shell 32 and the upper and lower series of tubes 62 and 65, respectively.

In operation, the boiler of my construction provides for the introduction of a supply of fuel into a relatively long and tubular type fire box, the flames from which travel rearwardly through the tubular fire box toward the rear end of the boiler and thence into the combustion chamber 40. The fire box is located relatively closely to the lower inner surface of the casing 20, but is spaced therefrom a sufficient distance to provide a cold water space therebetween which is dispersed by a series of cold gas conducting tubes, the term "cold gas," as being used herein, being intended to mean the gaseous products of combustion which have previously given off a substantial portion of their heat and are thereby now relatively cold as compared to the temperatures of the gases when first passing through and out of the fire box. Thus, the fire box of the boiler is disposed substantially within the lower portion of the boiler; and as indicated in the drawing, the upper level of the boiler water is at a substantial distance above the fire box. The first series of return tubes 62 for conveying the products of combustion from the combustion chamber forwardly to the front end of the boiler is disposed above and to each side of the fire box and is thus within the region of the hottest water of the boiler. Consequently, arrangement is made for conveyance of the gases while in their hottest condition through the hottest portion of the water in the boiler. Upon emergence of the gases from the forward ends of the upper tubes 62 they are directed downwardly through the hot gas chamber 40 and thence into the lower series of tubes 65 for conveyance rearwardly of the boiler to the outlet chamber 70. Thus arrangement has been made for conveying the gaseous products of combustion through the boiler in three separate alternately reversed passes, whereby ample opportunity is provided for transfer of their heat to the water in the boiler, and it will be seen that the last pass of gas is through the coldest portion of the boiler water. Thus, it will be apparent that opportunity for maximum transfer of heat has been provided, as distinguished from other types of boilers wherein the last pass of gas is through hotter portions of the boiler water. By reason of the present invention the relatively spent gases of the system pass through the coldest portion of the boiler water just before they emerge from the boiler and thus are enabled to give off still more of their heat with the result that a considerably lower stack temperature is experienced.

Previous types of multiple pass boiler constructions have involved the arrangement of the successive series of gas conveying tubes in upwardly stepped relation in order to insure uninterrupted gas flow through the system under the influence of heat convection forces of the heated gas stream. I have found, however, that by reason of my novel combination and arrangement of parts there is provided a gas circulating system within and through the water carrying portion of the boiler which functions in response to a combination of the thermo-syphon dynamic and static forces of the heated gas stream whereby smooth and uninterrupted gas circulation is obtained in an efficient manner in combination with the conveyance of the relatively spent gases through the coldest portion of the boiler water whereby maximum ultimate transfer of heat from the gases to the boiler water is obtained. This result is enhanced by my novel relative arrangement of the tubes of the opposed series 62 and 65. As explained hereinabove, the tube members of the upper series 62 are preferably provided of relatively small diameter and are multitudinous in number in order to provide maximum heat transfer tube wall area in the region of contact between the hot gases and the hottest portion of the boiler water. As the gas gives off its heat, however, it becomes denser and therefore requires less passage sectional area to accommodate it at the same velocity of travel. Also, because the cold gas is denser, it develops more resistance to motion through conveying tubing, and it is therefore desirable to convey the relatively colder gas through tubes of larger sectional dimension to provide a reduced ratio of wall contact surface to sectional area. I, therefore, prefer to provide the second series of tubes 65 of reduced number and of increased diameter, as compared to the tubes 62 and find that by this arrangement I provide an ideal system of gas conveyance through the boiler water from the standpoint of the gas flow problem, the velocity of the gas being substantially equal and uniform at all points. At the same time I provide adequate division of the cold portion of the boiler water body with channels conveying the relatively cold or nearly spent combustion gases so as to procure maximum heat transfer action therein. By reason of this heat transfer action which is provided for in the lower region of the boiler there is no "dead" cold water space therein, and the convection current water circulation of my boiler is positive and adequate enough to insure maximum thermal efficiency, as well as to prevent injury to the parts thereof which might otherwise occur under conditions of poor water circulation.

By reason of my multiple pass arrangement of fire box and fire tubes in combination with a natural draft stack, or a fan (of either the exhaust or forced draft type) I insure the smooth and uninterrupted flow of gaseous products of combustion through the boiler.

A modified form of my boiler is illustrated in Figs. 5 and 6; wherein a casing 125 is provided with a pair of tube sheets 127 and 128 respectively. The tube sheets are inset relative to the opposite ends of the casing to provide, in combination with the end closure plate 130 and 132 respectively, a combustion chamber 134 at the rear end of the boiler and a hot gas chamber 136 at the front end of the boiler. As in the case of the first form of construction described hereinabove, a fire box 138 is provided in the form of a tubular shell which extends inwardly from the front end closure plate longitudinally of the boiler and in spaced parallel relation with respect to the casing 125 to the rear closure plate 130.

The upper portion of the furnace shell 138 between the tube sheet 127 and the rear end closure plate 130 is cut away to provide for open communication between the interior of the furnace shell and the combustion chamber 134 and to allow free passage of heating gases therebetween.

In Fig. 5, the front tube sheet 128 is shown as being terminated intermediately of the vertical height of the boiler and joined to a plate 131 extending forwardly to the front plate 132 to provide the "wet front" type of construction generally known in the boiler art. As illustrated, the form of boiler construction shown in Figs. 5 and 6 is of the welded type as distinguished from the riveted type of construction shown as being employed in connection with the boiler of Figs. 1 to 4. However, it will be understood that the the features of either form of boiler construction may be employed in connection with either welding or riveting types of construction methods, and that either the wet or dry front arrangement may be employed in connection with either of the forms of construction shown in Figs. 1 to 4 or 5 and 6.

A series of fire tubes 140 are connected at their rear ends with the tube sheet 127 and in open communication with the combustion chamber 134, and are connected at their forward ends to the tube sheet 128 so as to be in open communication with the gas chamber 136. The members of the tube series 140 are disposed to each side of the upper portion of the furnace shell 138 and above the top portion thereof so as to provide for emergence of the gaseous products of combustion from the rear end of the fire box and thence outwardly and substantially upwardly through the combustion chamber 134 and into the return tubes 140 for conveyance therethrough toward the front end of the boiler through the hottest portion of the boiler water, for discharge into the upper portion of the gas chamber 136. A second series of tubes 141 is arranged between the lower portion of the furnace shell 138 and the casing 125, the front ends of which are connected to the tube sheet 128 and the rear ends of which are connected to the rear tube sheet 127. At the front end of the boiler the tubes 141 are in open communication with the lower portion of the gas chamber 136, and at the rear end of the boiler the tubes are in open communication with a collecting chamber portion 142 which is formed within the lower rear end portion of the casing by opposed portions of the tube sheet 127, the end closure plate 130, the casing 125, the furnace shell 138, and a pair of partition plates 143 extending from opposed portions of the shell 138 and the casing 125 (Fig. 6). The gas collecting chamber 142 is in open communication with a gas box 70 disposed adjacent the rear end of the boiler for distribution of the spent gas from the boiler to some form of draft producing means such as a natural draft stack 75 or a fan 71, as explained hereinabove in connection with the first form of construction described. It will be understood that the discharge of the fan 71 may be arranged to be directed to the stack 75 as by means of a by-pass duct 73, and that in lieu of the draft inducing means shown and described, that a draft forcing means such as a pressure fan at the fuel end of the boiler, or any other suitable form of draft producing means may be employed.

The gas combustion chamber 134 portion of the boiler may, if desired, be lined with insulating material as at 135, and the ceiling of the chamber is preferably disposed just above the line of the upper series of tubes 140 so as to obviate any substantial dead gas space in the upper portion of the combustion chamber. If desired, the lower portion of the furnace shell 138 may be lined with some refractory heat insulating material 139 to reduce the degree of heat exchange effect taking place between the lower portion of the furnace shell and the relatively cold portion of the boiler water therebelow so as to enhance the temperature differential between the extreme upper and lower portions of the boiler water body and thus to provide for maximum water circulation performance in response to convection current influences. As in the case of the first construction shown, a clean out door 114 may be provided in a side wall portion of the combustion chamber portion of the boiler.

I have illustrated the boiler as being adapted for fluid fuel consumption, but it will be understood that the principles of the invention are applicable with equal facility to boilers designed to use solid fuels or fuels of any type whatsoever. In any case, I prefer to arrange the fuel inlet and combustion chamber portion of the boiler in such manner that fuel combustion takes place substantially within the interior of the boiler and beyond the front tube sheet thereof. Thus, I provide substantially for the generation of the fuel produced heat entirely within the spaces encompassed by the boiler water body, and particular attention is called to the fact that by reason of my novel arrangement of parts there are no relatively hot boiler surfaces exposed to the exterior of the boiler. It will also be apparent that the path of the hot gases through my boiler is not so tortuous and restricted as to interfere with the smooth and uninterrupted flow thereof which is so necessary for efficient fuel combustion. At the same time, I have provided for maximum heat transfer efficiency inasmuch as I have arranged for the constant existence of a relatively wide difference between the temperature of the hot gas stream and the surrounding portion of the water body at all stages of the gas passage. Hence, I obtain maximum heat transfer performance, and the temperature of the gas being discharged from my boiler will be correspondingly lower as compared to the case of other boiler types. It will also be understood that by reason of my novel arrangement of parts I take advantage of the natural tendency of gases to expand and rise when their temperatures are increasing in combination with the fact that when the temperatures thereof are decreasing they tend to contract in volume and offer less resistance to downwardly directed flow; and that I also take advantage of the facts that a relatively large number of small sectioned tubes offer increased heat transfer area, and that a relatively small number of tubes of large sectional dimension provide a relatively increased composite gas conveying sectional area.

It will also be understood that the boiler of my construction is essentially of simple and rugged design and is of a type that may be made readily accessible for repair and replacement of parts; and yet by reason of my novel relative arrangement of the parts thereof my boiler is particularly nonsusceptible to deterioration such as by overheating of the parts. For example, it will be seen that I obtain the thermal advantages associated with the conveying of the fuel gases while in their hottest condition through the hottest portion of the boiler water body

without disposing the fire box shell immediately adjacent the upper level of the boiler water which would otherwise subject the furnace shell to the possibility of being burned in the event that the water receded below its normal level. Obviously, to replace a furnace shell would be relatively expensive, as compared to the replacement of a few tubes.

It will be understood that the principles of the invention are applicable to any other type of boiler or heater, or to heat exchange units of any character whatsoever. Although only a limited number of forms of the invention have been shown and described in detail it will be understood that the invention is not so limited but that various changes may be made therein without departing from the spirit of the invention or from the scope of the appended caims.

I claim:

1. A steam generating boiler comprising essentially a tubular horizontally elongate casing adapted to retain a supply of water therein, a tubular fire box extending inwardly of said casing from an end wall portion thereof in substantially axially parallel relation thereto and disposed within the intermediate lower portion of said casing, a first series of fire tubes connected to and in open communication with the inner end of said fire box and extending forwardly of said casing and disposed substantially within the uppermost portion of the body of said water supply, and a second series of tubes connected to and in open communication with the forward ends of said first mentioned series of tubes and extending rearwardly from the points of connection therewith, said second mentioned series of tubes being substantially disposed within the water space between the lower portions of said fire box and said casing and the members thereof being of less number and of greater sectional dimension than the tubes of said first mentioned series, the total composite sectional area of said second mentioned series of tubes being less than the total composite sectional area of said first mentioned series of tubes.

2. A steam generating boiler comprising a tubular horizontally elongate casing adapted to retain a supply of water therein, a tubular fire box extending inwardly of said casing from an end wall portion thereof in substantially axially parallel relation thereto and disposed within the intermediate lower portion of said casing, a first series of fire tubes connected to and in open communication with the inner end of said fire box and extending forwardly of said casing and disposed substantially within the uppermost portion of the body of said water supply, and a second series of tubes connected to and in open communication with the forward ends of said first mentioned series of tubes and extending rearwardly from the points of connection therewith, said second mentioned series of tubes being substantially disposed within the water space between the lower portions of said fire box and said casing and the members thereof being of less number and of greater sectional dimension than the tubes of said first mentioned series.

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