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Brevet canadien / Canadian Patent

3,048,401
Numéro de brevet
Patent number

Le commissaire aux brevets a accordé un brevet pour l'invention décrite dans le mémoire descriptif portant le numéro de brevet susmentionné. Le mémoire descriptif est accessible dans la Base de données sur les brevets canadiens sur le site Web de l'Office de la propriété intellectuelle du Canada.

The Commissioner of Patents has granted a patent for the invention described in the specification under the above-noted patent number. The specification is accessible in the Canadian Patents Database on the website of the Canadian Intellectual Property Office.

Commissaire aux brevets
Commissioner of Patents

Titre de l'invention / Title of invention
ELEMENT DE SURCHAUFFE ANNULAIRE POUR CHAUDIERES A TUBES DE FUMEE

ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS

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Date de l'octroi et de la délivrance du brevet / Patent grant and issue date
2022-06-21

Date de dépôt de la demande / Filing date of the application
2017-12-09

Date d'accessibilité au public / Date application open to public inspection
2018-06-21

Canada

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Canadian Intellectual Property Office

CA 3048401 C 2022/06/21

(11)(21) 3 048 401

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2017/12/09
(87) Date publication PCT/PCT Publication Date: 2018/06/21
(45) Date de délivrance/Issue Date: 2022/06/21
(85) Entrée phase nationale/National Entry: 2019/06/25
(86) N° demande PCT/PCT Application No.: US 2017/065485
(87) N° publication PCT/PCT Publication No.: 2018/111730
(30) Priorité/Priority: 2016/12/16 (US15/381,682)

(51) Cl.Int./Int.Cl. *F22G 1/02* (2006.01),
F22G 3/00 (2006.01)

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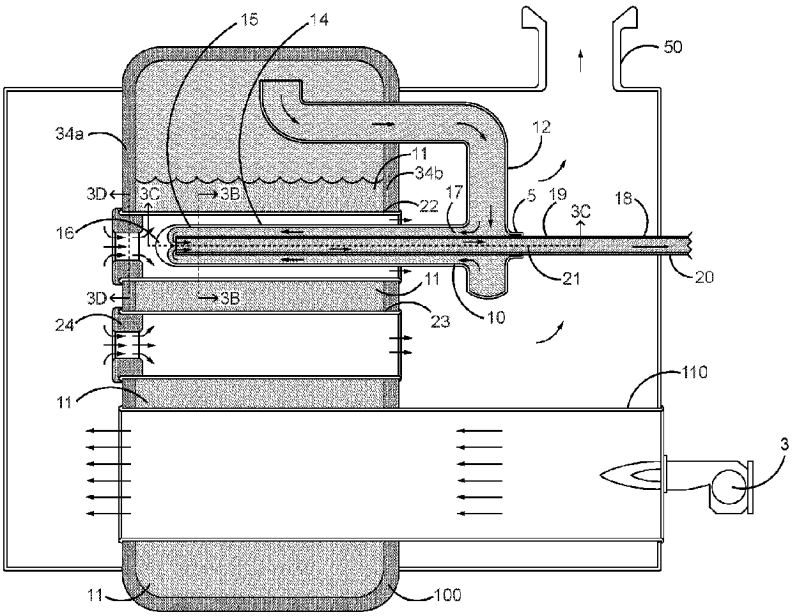
(54) Titre : ELEMENT DE SURCHAUFFE ANNULAIRE POUR CHAUDIERES A TUBES DE FUMEE
(54) Title: ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS



(57) Abrégé/Abstract:
An annular superheater element (10) for superheating steam within firetubes (22) of firetube boilers comprising concentric inner and outer tubes and a specially designed return end cap (16). Saturated steam introduced into the outer tube (14) of said superheater element is superheated while traveling towards the burner end of the tube, is directed into the inner tube (18) by means of the return end cap (16), and travels away from the burner side of the element (10) where it is exhausted for use as superheated steam. While traversing the inner tube, the superheated steam gives off heat energy through the wall of the inner tube to the steam traveling in the outer tube towards the burner end of the tube, conserving energy. The improved superheater element produces superheated steam more efficiently, with less fuel, and steam capable of doing more work, than conventional superheater elements and can be used to retrofit existing firetube type boilers.

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CA 3048401 A1 2018/06/21

(21) 3 048 401

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2017/12/09
(87) Date publication PCT/PCT Publication Date: 2018/06/21
(85) Entrée phase nationale/National Entry: 2019/06/25
(86) N° demande PCT/PCT Application No.: US 2017/065485
(87) N° publication PCT/PCT Publication No.: 2018/111730
(30) Priorité/Priority: 2016/12/16 (US15/381,682)

(51) Cl.Int./Int.Cl. *F22G 1/02* (2006.01),
F22G 3/00 (2006.01)

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(54) Titre : ELEMENT DE SURCHAUFFE ANNULAIRE POUR CHAUDIERES A TUBES DE FUMEE
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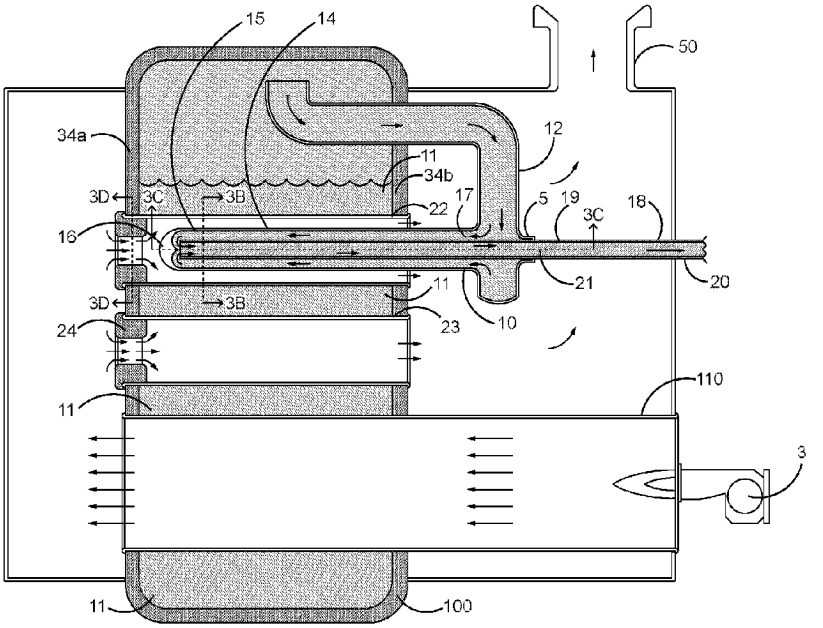

FIG. 3A

(57) Abrégé/Abstract:
An annular superheater element (10) for superheating steam within firetubes (22) of firetube boilers comprising concentric inner and outer tubes and a specially designed return end cap (16). Saturated steam introduced into the outer tube (14) of said superheater element is superheated while traveling towards the burner end of the tube, is directed into the inner tube (18) by means of the return end cap (16), and travels away from the burner side of the element (10) where it is exhausted for use as superheated steam. While traversing the inner tube, the superheated steam gives off heat energy through the wall of the inner tube to the steam traveling in the outer tube towards the burner end of the tube, conserving energy. The improved superheater element produces superheated steam more efficiently, with less fuel, and steam capable of doing more work, than conventional superheater elements and can be used to retrofit existing firetube type boilers.

ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This international application claims priority on U.S. Patent Application no. 15/381,682 filed December 16, 2016.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

[0002] The invention described herein was not made pursuant to a government agency grant or contract. No government funds were utilized in the described invention.

FIELD OF THE INVENTION

[0003] The present invention relates to superheaters for firetube-style steam boilers. More specifically, the subject invention describes an annular superheating element capable of producing superheated steam more efficiently than currently available superheating boilers.

BACKGROUND OF THE INVENTION

[0004] Firetubes are tubes used in some steam boilers to convey heated gases from one tube sheet to an opposite tube sheet of a boiler. Heated gases traverse the firetube, conducting heat through the firetube's wall and transferring heat energy to the water that surrounds the firetube. Gases exit the opposite tube sheet at a significantly lower temperature.

[0005] Steam boilers capable of producing superheated steam comprise superheater elements having steam flowing within the element tube, and with hot gases within firetubes flowing on the outside of the superheater elements.

[0006] A superheater element consists of a superheater tube that conducts the flow of steam into and out of a firetube in order to impart heat energy from the high temperature gases in the firetubes to the saturated steam inside the superheater elements, causing the steam to exit the superheater element with more useful energy per unit volume of steam than if the steam were not superheated.

[0007] Currently, most commercial steam boilers 55 are either of the scotch wet-back horizontal firetube type, illustrated by example in FIG. 1A, or the scotch dry-back horizontal firetube type, illustrated by example in FIG. 1B. In these steam boilers, a burner source 3 burns fuel in a relatively large furnace tube and heats the gas therein. The high temperature gases exit the furnace tube, execute a 180 degree turn, and flow through relatively small diameter firetubes stretched between two tube sheets. Tube sheets are plates that secure the

pressure boundaries of the firetubes and hold the firetubes in place. The scotch wet-back horizontal firetube boiler illustrated in FIG. 1A has three tube sheets, whereas the scotch dry-back horizontal firetube boiler illustrated in FIG. 1B has two tube sheets.

[0008] The current boiler art uses one furnace tube of appropriate diameter to promote the most efficient combustion for the design steaming capacity and as many small diameter tubes as possible to create large surface area to accommodate efficient convective heat transfer rates across the tube walls from the heated furnace gases. In the case of horizontal firetube boilers, illustrated in FIGS. 1A and 1B, the furnace tube and the many small diameter gas firetubes are surrounded by water in a steel cylinder boiler designed to withhold the design boiler pressure. As the high temperature gases flow through the one large diameter furnace tube and multiple smaller diameter firetubes, the high temperature gases give up heat to boil water 11 inside the pressure boundaries of the boiler. The saturated steam of the boiling water 11 collects in the steam space at the top portion of the boiler and exits through a valve at the top wall of the boiler.

[0009] Some boilers are designed to circulate the heated furnace gases several times back and forth through different banks of tubes, called "passes," in order to extract as much heat as possible before exhausting the gases out the smokestack 50 to the atmosphere.

Boilers of the locomotive type combust the fuel in a firebox and exhaust the gases after only one pass through the firetubes. The scotch wet-back horizontal firetube steam boiler shown in FIG. 1A has three passes and the scotch dry-back horizontal firetube steam boiler shown in FIG. 1B has two passes.

[0010] The steam generating capacity of a given boiler is dictated by the size of the space the boiler can occupy. The boilers are typically cylindrical, being the strongest practical shape to contain pressurized fluids. Greater steam generating capacity is achieved by making the boiler shells larger in diameter and increasing the distance between the tube sheets.

[0011] Efficiency of the boiler is increased by diverting the gases through several passes to increase the tube surface area the gases are exposed to before exhausting the heated gases through smokestack 50.

[0012] The laws of physics regarding heat transfer and gas flow dictate the cross-sectional area for a given firetube to achieve the most efficient combustion and heat transfer. Firetubes with smaller diameters have less volume for the high temperature gases to flow through but have greater surface area to volume ratios which means more surface area to absorb heat. Optimal firetube efficiency is achieved by balancing the amount of hot gases flowing in a given period of time verses the overall surface area for heat transfer.

[0013] Superheated steam at a given pressure has a higher temperature than the temperature at which water boils at that same pressure. For example, at 14.7 pounds per square inch (1 bar) (sea level), superheated steam would have a temperature higher than 212°F (100° C), which is the temperature of regular saturated steam from boiling water at that pressure; or at 150 pounds per square inch (10 bar), which is approximately ten times sea level atmospheric pressure, superheated steam will have a temperature higher than 366°F (186° C), which is the temperature of regular saturated steam from boiling water at that pressure. To superheat steam, it must be collected from the boiler and subjected to additional heat input from either an external heat source or the furnace gases.

[0014] The advantage of superheated steam is the ability to transfer more thermal energy from the boiler source to the destination at a given pressure with less boiled water. This allows more energy to be transmitted with the same amount of steam without increasing pressure or the infrastructure of the piping system.

[0015] Superheating steam in firetube boilers is well known in the art. Typical prior art embodiments comprise adding significantly larger firetubes in the boiler, with a small diameter superheater tube filled with steam passing down within a single firetube from one end and a small radius u-bend in the superheater tube to send the steam back out the same firetube in the opposite direction. The superheater tubes reverse direction inside the large diameter tubes at least once, and in some embodiments twice. FIG. 2A depicts an example of a one-directional flow firetube superheater with multiple u-turns or passes. A portion on the left of the one directional flow firetube superheater tube is cut out to illustrate the inside structure of one of the u-turn bends in the superheater tube.

[0016] Among the disadvantages of these prior art one-directional flow superheater tubes with one or more u-turn bends are:

- They require large diameter firetubes, lowering the total number of firetubes that can be utilized in a given diameter boiler for a specific sized boiler shell. The total heating surface for water to cause steam generation is thereby reduced, reducing the boiler steam generating capacity.
- As the steam flows through the superheater element making multiple passes through the firetube, with each pass being from the low temperature end to the high temperature end of the firetube and then back to the low temperature end, the temperature of the furnace gases drop exponentially. The steam in the outbound superheater tube, being heated to a high degree in the high temperature end of the

firetube, has a higher temperature than the gases in the low temperature end of the firetube. At a certain point along the firetube, the steam in the outbound superheater tube will have a higher temperature than the continually cooling adjacent furnace gases. At this point, the superheating process becomes counterproductive as the superheater tube is now giving up heat to the furnace gases that are exiting the firetube, possibly to the exhaust of the boiler. This thermodynamic effect is illustrated in the prior art firetube boiler schematic of FIG. 2B, and explained in more detail in below.

[0017] An object of this subject invention is to provide a superheater element that overcomes the disadvantages of the currently available superheater elements.

[0018] A further object of the current invention is to superheat steam without requiring an additional external heat source to heat the saturated steam into superheated steam.

[0019] A further object of the current invention is to superheat steam using the furnace gases used to heat the boiler water into saturated steam.

[0020] A further object of the current invention is to provide a superheater element that produces superheated steam more efficiently than currently available superheater elements.

[0021] A further object of the subject invention is to provide a superheater element wherein the superheated steam circulating within the firetube does not lose any heat energy to the firetube gases.

[0022] A further object of the subject invention is to provide a superheater element that uses fuel more efficiently than currently available superheater boilers.

[0023] A further object of the subject invention is to provide a superheated boiler that can produce more superheated steam with less fuel, produce superheated steam at a higher temperature with the same amount of fuel, or produce superheated steam having the potential to do more work with the same amount of fuel.

[0024] A further object of the subject invention is to provide an improved superheater element that can be easily and inexpensively retrofitted into conventional firetube boilers.

SUMMARY OF THE INVENTION

[0025] These objects are accomplished in the present invention, an annular superheater element that re-circulates superheated steam in a manner to increase the efficiency of the heating provided by the boiler firetube. The present invention solves the problems identified in the prior art. The improved annular superheating element of the present invention produces temperatures of superheated steam having a materially higher temperature using the same

energy input, superheated steam at the same temperature with considerably less energy input, and superheating steam capable of doing more work relative to currently available firetube boilers using the same amount of fuel. The annular superheater element of the subject invention conserves energy and the expense of fuel, producing superheated steam that can do more work with greater efficiency for a given amount of fuel.

[0026] The superheater element of the subject invention comprising two concentric tubes - an outer tube and an inner tube - and a return end cap. The return end cap causes the superheated steam flowing within the annular channel bounded by the outer and inner tube to be directed and returned through the inner tube.

[0027] The annular superheater element of the present invention is materially different from annular superheater elements described in the prior art in a number of important respects including, without limitation, the improved superheater element's ability to efficiently absorb thermal energy in the first steam pass between the inner and outer tubes, and a specially designed return end cap that efficiently and reliably redirects the superheated steam from the first pass channel into the inner tube. As used herein, first pass channel means the annular steam path bounded by the outer tube and the inner tube, which resides concentrically about a secondary inner tube (defining the second pass channel) of smaller diameter.

[0028] The superheater element of the subject invention can be inserted in a firetube of a conventional firetube-style boiler. The saturated steam within the element is conducted through the first pass channel to the return end cap which redirects the flow through the second pass channel.

[0029] The annular configuration of the superheater element functions such that the external temperature of the superheater element, the firetube, and the saturated steam, are all at the same temperature at the tube sheet end where the furnace gases exit. As such, steam in the superheater element does not lose any heat to the surrounding furnace gases.

[0030] The steam temperature within the superheater element first pass channel increases as the steam flows toward the high temperature (furnace gas entrance) end of the firetube. The highest steam temperature is achieved at the end of the superheater element where the return end cap reverses the steam flow to cause the steam to flow into the inner tube. As the steam is diverted and flows through the second pass channel, the higher temperature steam imparts heat to the lower temperature incoming steam traveling in the opposite direction in the first pass channel. The incoming saturated steam traveling within the first pass channel is heated both by the heat of the furnace gases being absorbed through the outside wall of the

outer tube and the heat of the higher temperature superheated steam in the second pass channel that is being absorbed through the wall of the inner tube. This configuration, where the highest difference in temperatures exists across the heating surfaces, is the most efficient configuration possible for heat transfer.

[0031] The final superheat, that is, the temperature of the superheated steam exiting the superheater element, will be determined by the steam flow rate together with the temperature and flow rate of the furnace gases at the high temperature end of the firetube. The final superheated steam flows out through a nozzle formed within the saturated steam intake manifold, connecting the superheated steam to the superheated steam output manifold.

[0032] Among the advantages of the annular superheating element configuration of the instant invention are:

- This configuration of tubing and steam flow contained in a boiler firetube provides the most efficient heat transfer of hot furnace gases to superheat steam.
- A plurality of individual superheater elements can be connected together to provide uniform temperature superheated steam up to the design steaming capacity of a boiler.
- The superheater elements of the subject invention can be installed (retrofitted) in existing boilers or utilized in boilers of new construction.

[0033] The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0034] FIGS. 1A and 1B illustrate in schematic fashion the furnace gas and steam flow of two embodiments of conventional horizontal type firetube boilers. FIG. 1A is an example of a scotch wet-back horizontal firetube boiler and FIG. 1B is an example of a scotch dry-back horizontal firetube boiler.

[0035] FIG. 2A depicts a traditional one-directional flow firetube superheater with multiple u-turns or passes.

[0036] FIG. 2B is a schematic illustrating the thermodynamic effect of the superheated steam upon the exhaust gases in the context of the single tube of the traditional one-directional flow firetube superheater depicted in FIG. 2A.

[0037] FIG. 3A is a longitudinal cross-sectional view showing in schematic form a preferred embodiment of an annular superheater element of the subject invention within a horizontal-type firetube boiler.

[0038] FIG. 3B is a transverse sectional view of the annular superheater element of the subject invention taken along Line 3B shown in FIG. 3A.

[0039] FIG. 3C is a longitudinal cross-sectional view of the annular superheater element of the subject invention taken along Line 3C shown in FIG. 3A.

[0040] FIG. 3D is a transverse sectional view of the tube sheet, firetube, and choke thimble taken along Line 3D in FIG. 3A.

[0041] FIG. 4A is larger-scale view showing the return end cap and portions of the inner and outer tubes of the annular superheater element of the subject invention

[0042] FIGS. 4B-4D are perspective views of the specially designed return end cap of the subject invention. FIG. 4B is a return end cap with an inner surface in the shape of half a horn torus. FIG. 4C is a return end cap with an inner surface in the shape of half of a hyperbolic curve rotated around a center axis. FIG. 4D is a return with an inner surface with the shape of a parabolic curve rotated around a center axis.

[0043] FIG. 5 is a schematic view showing a further embodiment of the annular superheater element of the subject invention comprised of multiple annular superheater elements.

[0044] FIG. 6 is a chart showing the temperature of the furnace gases in degrees Fahrenheit within the firetube as a function of the distance from the tube sheet on the high temperature side of the firetube.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0045] One preferred embodiment of the superheater element of the subject invention is illustrated in FIG. 3A, a longitudinal cross-sectional view, FIG. 3B, a transverse sectional view on Line 3B in FIG. 3A, and FIG. 3C, a longitudinal cross-sectional view taken on Line 3C in FIG. 3A. As shown in FIGS 3A through 3C, an improved annular superheater element 10 is comprised of a saturated steam inlet manifold 12, an outer tube 14, a specially designed return bend end cap 16, an inner tube 18, and a superheated steam outlet manifold 20. The first pass channel 17 is the annular steam path bounded by outer tube 14 and inner tube 18 and a second pass channel 21 is the steam path bounded by inner tube 18.

[0046] FIG. 3A shows a scotch dry-back horizontal firetube steam boiler 55 with two passes through the water 11 held in cylindrical boiler 100. The first pass comprises of a

portion of furnace tube 110 and the second pass comprising of two firetubes 22 and 23, which are bounded by tube sheets 34a and 34b. Superheater element 10 of the subject invention has been inserted into firetube 22, whereas firetube 23 has been left empty.

[0047] Fuel is burned at the burner source 3, which is located on one side of the furnace tube 110. The burning of the fuel in burner source 3 heats the air within furnace tube 110. The high temperature gases, represented by arrows, flow through furnace tube 110, making a first pass through water 11. On the first pass, heat from the high temperature gases is absorbed through the walls of furnace tube 110 into water 11.

[0048] On the second pass through water 11, the high temperature gases traverse through firetubes 22 and 23. On the second pass, heat from the high temperature gases is absorbed through the walls of the firetubes 22 and 23. The heat absorbed by the water during the first and second passes causes water 11 to boil and make saturated steam. The saturated steam created by the boiling water rises to the top of boiler 100 and is channeled into saturated steam inlet manifold 12 into superheater element 10.

[0049] As illustrated in FIG. 3A, superheater element 10 extends into cylindrical boiler 100, with a portion of tubes 14 and 18, and all of return end cap 16, inside firetube 22 which is bounded by tube sheets 34a and 34b. While superheater element 10 could be inserted into firetube 22 at either side, in the preferred embodiment of the subject invention, superheater element 10 is inserted into the side of firetube 22 bounded by tube sheet 34b, which is the side that the furnace gases exit firetube 22. Accordingly, the furnace gases are hottest at return end cap 16 side of superheater element 10 and cooler at the side with inlet manifold 12.

[0050] The saturated steam, also represented by arrows, enters steam manifold 12, flows through manifold 12 into outer tube 14 of superheater element 10. The saturated steam flows toward the side of firetube 22 bounded by tube sheet 34a through first pass channel 17, which is the annular steam path bounded by outer tube 14 and inner tube 18, until it reaches return end cap 16. Return end cap 16, which is more fully described below, causes the steam flow to change direction 180 degrees diverting the steam flow into inner tube 18 of superheater element 10. Thereafter, the steam in inner tube 18 flows away from tube sheet 34a in the same direction as the furnace gases, towards superheater outlet manifold 20. Inner tube 18 passes through a nozzle 5 formed within saturated steam inlet manifold 12.

[0051] The saturated steam within outer tube 14 begins to absorb heat from the furnace gases through the wall 15 of tube 14 starting from where element 10 enters firetube 22. As the steam absorbs heat, the temperature of the steam within first pass channel 17 increases until it reaches return end cap 16. Thus, as the furnace gases flow through firetube 22, heat is

transferred from the gases to both water 11 surrounding firetube 22 and to the saturated steam in first pass channel 17 through wall 15 of outer tube 14. When the superheated steam reaches return end cap 16, it is significantly hotter than the desired output temperature.

[0052] The steam is the hottest as it passes through return end cap 16. Return end cap 16 reverses the direction of the flow and directs the flow into second pass channel 21, which is the steam path bounded by inner tube 18. As the steam traverses second pass channel 21 from return end cap 16 towards the superheater outlet manifold 20, heat is transferred across wall 19 of inner tube 18 to the steam flowing within first pass channel 17. Accordingly, the steam in first pass channel 17 is heated by both the high temperature gases flowing through firetube 22 and the superheated steam flowing through second pass channel 21.

[0053] Outer tube 14, inner tube 18, and return end cap 16 can be constructed of a variety of materials capable of withstanding high pressure and temperatures and having good thermal conduction characteristics. Accordingly, cast and wrought iron, a material predominately used in prior art superheater elements but which transfers heat inefficiently and has low strength, is not a good choice of material for the concentric tubes of improved superheater element 10. According to preferred embodiments, outer tube 14 and inner tube 18 would be made from one or more of the following materials: high quality carbon steel, stainless steel, and steel with chromium, molybdenum, and/or manganese alloys.

[0054] Similarly, it is important that there is no space or other obstruction or insulation materials between concentric tubes 14 and 18, as efficient transfer of heat between tubes 14 and 18 through wall 19 of inner tube 18 is essential to the proper functioning of superheater element 10.

[0055] Superheater element 10 can be inserted into firetubes of conventional firetube boilers, the subject invention not being limited to any particular embodiment or style of firetube boiler.

[0056] The diameter and length of tubes 14 and 18 and the length of superheated element 10 extending into the firetube 22 can be varied to change the temperature and steam flow rate in pounds per minute of the superheated steam output. Of the heat energy absorbed from the furnace gases, about two-thirds is absorbed to boil water 11 to make steam and about one-third is absorbed to superheat the steam. The number of superheater elements in the boiler and the length of the superheated element extending into the firetube will determine, together with other parameters, the final superheated steam temperature.

[0057] A preferred embodiment of the subject invention also anticipates the insertion of choke thimble 24 into one or more firetubes. Choke thimble 24 is inserted into the side of the

firetube where the high temperature gases enter the firetube. The purpose of choke thimble 24 is to provide even furnace gas flow volumes between firetubes with and without superheater elements. Choke thimble 24 increases gas velocity and induces turbulent gas flow which increases heat transfer rate. Use of choke thimble 24 in those firetubes without superheater elements also prevents furnace gases from taking the path of least resistance through the empty firetubes without superheater elements, which would rob the heat energy from the superheater elements.

[0058] In the preferred embodiment illustrated in FIG. 3A, both firetubes 22 and 23 have choke thimbles 24. In another preferred embodiment illustrated in FIG. 5, two firetubes have choke thimbles while one firetube containing a superheater element does not. In a preferred embodiment, choke thimbles are made with heat resistant materials, such as ceramic. Metal choke thimbles have a short service life due to exposure to high temperatures.

[0059] FIG. 3B is a transverse sectional view of superheater element 10 taken along Line 3B in FIG. 3A and illustrates the concentric structure of the superheated element of the instant invention. The outermost ring is firetube 22. Inside the wall of fire tube 22 is outer tube 14. Inside wall 15 of outer tube 14 is inner tube 18. High temperature gases flow between the annular channel created between the wall of fire tube 22 and outer tube 14. First pass channel 17 is the channel bounded by outer tube 14 and inner tube 18 and second pass channel 21 is bounded by inner tube 18.

[0060] Referring to FIG. 3B, heat energy from the high temperature gases flowing between the annular channel created between the wall of fire tube 22 and outer tube 14 is absorbed through wall 15 of outer tube 14 heating the steam flowing through first pass channel 17. Similarly, heat energy from the higher temperature steam flowing between second pass channel 21 is absorbed through wall 19 of inner tube 18 heating the steam flowing through first pass channel 17.

[0061] FIG. 3C is a longitudinal cross-sectional view of superheater element 10 taken along Line 3C shown in FIG. 3A showing wall 15 of outer tube 14, first pass channel 17, wall 19 of inner tube 18, second pass channel 21, and nozzle 5. FIG. 3C also shows an inner surface 42 and a center 44 of return end cap 16, which are more fully described below.

[0062] FIG. 3D is a transverse sectional view taken along Line 3D in FIG. 3A showing choke thimble 24 fire tube 22, and a portions of tube sheet 34a. Choke thimble 24 reduces the flow of high temperature gases that enter firetube 22 by forcing the high temperature gases through a smaller diameter hole in its center. The hole in the center of the choke

thimbles can vary in size. A larger hole would allow the gases through at a faster rate, whereas a smaller hole would allow the gases through at a slower rate.

[0063] FIG. 4A is larger-scale sectional view taken along Line 4A in FIG. 3C showing the return end cap and portions of the inner and outer tubes of the annular superheater element of the subject invention. The purpose of return end cap 16 is to reverse the steam flow. The flow direction of steam in first pass channel 17 is changed 180 degrees and directed into second pass channel 21. Anytime steam is required to change direction, a force is exerted on the pipe wall or other surface causing the steam to change in direction. The impact of the steam flowing essentially into a dead end creates tremendous forces and severe turbulence. This force is proportional to the mass flow rate of the steam and is termed the velocity pressure. At nominal steam flow rates typical with steam piping external to the boiler, this force can exceed eleven times the force produced by the nominal pressure of the steam in the boiler and the superheater element components not subject to this velocity pressure. Failure to properly design and construct the return end cap to deal with the velocity pressure aspect of the steam flow reversal will result in significant erosion of the metal in the return end cap and unacceptable service life of the superheater element.

[0064] Return end cap 16 of the present invention is specially designed to prevent the serious turbulence and eddy currents described above that would otherwise produce erosion to return end cap 16 and the walls of tubes 14 and 18. Return end cap 16 acts like a vane of an impulse turbine to efficiently reverse and redirect the steam flow.

[0065] Return end cap 16 is rotationally symmetric at all angles of rotation along an axis shown as Line 4A in FIG. 3C. Return end cap 16 has inner surface 42 that has center 44, which extends towards inner tube 18. Inner surface 42 is a concave, smooth and continuous surface. In the preferred embodiment shown in FIG. 4B, the profile of inner surface 42 takes the shape of one half of a horn torus, which is the surface generated by revolving a circle about an axis of revolution that is tangent to the circle. According to alternative embodiments, inner surface 42 can also take the shape of a hyperbolic curve rotated about an axis of revolution, as illustrated in FIG. 4C or the shape of a parabolic curve rotated about an axis of revolution, as illustrated in FIG. 4D.

[0066] In a preferred embodiment, return end cap 16 can be made from turbine blade material such as a high carbon alloy steels that require special heat treatment to achieve a very hard surface resistant to erosion from the high pressure, high velocity steam flow. Because boiler codes do not allow the metallurgical elements required for high carbon alloy

steels to be used in pressure boundaries, return end cap 16 may be fabricated from high carbon alloy steel encased in code compliant steel.

[0067] The inefficiencies of traditional one directional flow firetube superheaters of the type illustrated in FIG. 2A is shown in FIG. 2B. FIG. 2A shows a traditional one directional flow firetube superheater 30 is comprised of a single tube 32 having three 180 degree bends. FIG. 2B shows conventional superheater 30 in schematic, showing the temperature of the firetube gases at various distances away from the side of firetube where the high temperature gases enter and the temperature of the superheated steam at various points along tube 32.

[0068] As can be seen in FIG. 2B, the superheated steam in tube 32 demonstrates temperatures greater than the surrounding firetube gases on the side of the firetube closest to where the high temperature gases enter the firetube, the furnace side, and temperatures lower than the surrounding firetube gases on the side of the firetube further away from where the high temperature gases enter the firetube. As such, after the first and third passes (bends), the superheated steam within tube 32 on the side away from the furnace loses heat through tube 32 to the gases within the firetube. This loss of heat energy, from the superheated steam to the furnace gases, results in output steam of a lower temperature and makes the process of heating superheated steam less efficient.

[0069] FIG. 5 is an illustration showing a further embodiment of the annular superheater element of the subject invention comprised of multiple annular superheater elements and the thermodynamic effect of the superheated steam upon the high temperature gases. The temperature of the furnace gases in degrees Fahrenheit within the firetube as a function of the distance from the tube sheet on the high temperature side of the firetube is illustrated in the graph shown in FIG. 6.

[0070] Efficiency and rate of heat transfer is exponentially proportional to the difference in the heat temperatures. As such, about two-thirds of the available heat is given up to the boiler in the first one-third of the firetube length from the furnace end.

[0071] In the prior art example shown in FIG. 2B, the superheater tube traverses the firetube four times attempting to absorb heat from the furnace gases. For approximately 30% of the superheater tube length, those areas where temperatures are indicated in bold italic font in FIG. 2B, the temperature of the superheated steam in the tube exceeds the temperature of the furnace gases in the firetube.

[0072] Referring to FIG. 5, saturated steam enters superheater element 10 through inlet manifold 12 at 366° F at 150 psi. As the steam travels in first steam pass channel 17, towards the return end cap 16, heat is transferred through outer tube 14 from the hotter furnace gases

flowing within firetube 22, heating, in this example, the saturated steam from 366°F to 950°F at 150 psi. At the side of superheater element 10 closest to where the high temperature gases enter firetube 22, where the superheated steam is returned into inner tube 18 by return end cap 16, the temperature of the superheated steam in outer tube 14 is the same as the temperature of the superheated steam in inner tube 18.

[0073] Still referring to FIG. 5, as the superheated steam flows down second steam pass channel 21 in inner tube 18 from the side of element 10 closest to where the high temperature gases enter firetube 22 to the inlet/outlet side of element 10, the temperature of the superheated steam drops from, in this example, 950°F to 650°F at 150 psi, the temperature and pressure at which it exits from outlet manifold 20. During the latter portion of this flow, the temperature of the superheated steam within the steam second pass in the inner tube 18 is higher than the temperature of the superheated steam within first pass channel 17 between the outer tube 14 and the inner tube 18 and heat is transferred from the superheated steam within inner tube 18 to the superheated steam within outer tube 14, through inner tube 18, rendering the process of superheating steam more efficient. This is in contrast with the thermodynamics illustrated for traditional firetube element 30 in FIGS. 2A and 2B wherein, during the transit of superheated steam from the return end cap side of the element to the exhaust side of the element, the superheated steam loses heat energy to the furnace gases that eventually are exhausted, rather than to the superheated steam that is the desired product of the process.

[0074] Shown in FIG. 5, again by way of a schematic, is an alternative embodiment annular superheater element wherein a plurality of interconnected annular superheater elements 10 are used. As with the single annular element embodiment described in FIG. 3A, saturated steam enters inlet manifold 12. From there, however, the steam flows through one of two outer tubes 14, towards the side of the firetube bounded by tubesheet 34a, is returned by return end cap 16, flows back towards the side of the firetubes bounded by tubesheet 34b through inner tube 18, which passes through nozzle 5 formed within saturated steam inlet manifold 12 and then exits together through outlet manifold 20.

[0075] Conventional firetube boilers can be easily and inexpensively retrofitted with superheater element 10 to produce superheated steam capable of doing substantially more work with less fuel than the firetube boiler before conversion. To retrofit a conventional firetube boiler, superheater elements 10 are inserted into one or more of the existing firetubes. Elements 10 are inserted through tube sheets and positioned within firetubes so that the intake saturated steam manifold side of element 10 is on the side of the firetube in which the high

temperature gases flowing within exit the firetube. In this configuration, the saturated steam within first pass channel 17 will flow towards the hotter furnace gases, while the saturated steam within second pass channel 21 will flow away from the hotter furnace gases.

[0076] When retrofitting conventional firetube boilers, superheater element 10 is sized in length and diameter to be compatible with the diameter and length of the firetubes within the boiler to be retrofitted. Choke thimbles 24 are inserted or removed as appropriate to the firetube pattern.

[0077] Although the embodiment of the improved annular superheater element illustrated in FIG. 5 is comprised of only two elements 10, the improved superheater element of the subject invention can be used in sets of three or in any number appropriate to the size and other structural parameters of the firetube boiler in question. Several multiple individual superheater elements may be connected to a common manifold creating a bank of superheater elements. Multiple banks of superheater units may be connected to a larger manifold for delivery of the superheated steam to the boiler outlet.

[0078] Further, each of the multiple elements can have its own inlet and outlet manifold, or some of the elements can share a manifold whereas others may not. In addition, although superheater elements 10 in FIG. 5 are inserted into individual firetubes 22, more than one superheater element 10 can be inserted into a single firetube without departing from the intention and scope of the instant invention.

SUMMARY AND SCOPE

[0079] As described above and illustrated in the accompanying figures, the improved annular superheater element of the instant invention allows for the more efficient production of superheated steam using conventional firetube-type boilers. The improved element can produce more superheated steam of a given volume and temperature with less fuel, can produce the same volume of superheated steam of a higher temperature using the same amount of fuel, and can produce superheated steam that is capable of doing more work relative to prior art firetube boilers using conventional superheater elements.

[0080] The improved annular superheater elements of subject invention can be used to retrofit existing firetube boilers or can be used in boilers of new construction. Given that a report prepared by the Energy and Environmental Analysis, Inc. dated May 2005 for the United States government estimates that there are approximately 120,000 commercial firetube style boilers currently in use in the United States alone (see table below), the potential for increased work and energy and fuel savings that can be realized by converting

existing firetube boilers is considerable.

Commercial Boiler Inventory

Building Type	Number of Boilers	Boiler Capacity (MMBtu/hr)	Average Size (MMBtu/hr)
Office	28,030	297,090	10.6
Warehouse	5,365	72,385	13.5
Retail	5,585	47,230	8.5
Education	35,895	128,790	3.6
Public Assembly	7,280	55,205	7.6
Lodging	10,545	140,830	13.4
Health	15,190	317,110	20.9
Other	11,900	88,970	7.5
Total	**119,790**	**1,147,610**	**9.6**

[0081] Unless otherwise indicated, all numbers, dimensions, materials and so forth used in the specification and claims are to be understood as being examples and not limitations, and in any event, not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims.

[0082] The terms "a," "an," "the," and similar references used in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein is intended merely to better illuminate the invention and does not pose a limitation on the scope of any claim. No language in the specification should be construed as indicating any non-claimed element essential to the practice of the invention.

[0083] Certain embodiments are described herein, including the best mode known to the inventor for carrying out the invention. Of course, variations on these described embodiments will become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventor expects skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than specifically described herein.

[0084] Accordingly, the claims include all modifications and equivalents of the subject matter recited in the claims as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is contemplated unless otherwise indicated herein or otherwise clearly contradicted by context.

[0085] By way of example, and not limitation, the temperatures and pressures described in the specification and figures and given as examples. A variety of temperatures and pressures for superheated steam within and produced by firetube boilers are known in the art, and all such temperatures and pressures may be practiced in the instant invention. Further, while the improved annular superheater element of the subject invention has been described and claimed in the context of traditional horizontal-type firetube boilers, the improved superheater element can be used in other types of firetube boilers as well as in boilers without firetubes.

[0086] In closing, it is to be understood that the embodiments disclosed herein are illustrative of the principles of the claims. Other modifications that may be employed are within the scope of the claims. Thus, by way of example, but not of limitation, alternative embodiments may be utilized in accordance with the teachings herein. Accordingly, the claims are not limited to embodiments precisely as shown and described.

CLAIMS

1. A superheater element for superheating steam within a firetube of a firetube boiler comprising:

an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube;

and a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube.

2. A superheater element of claim 1 wherein said interior face of said return is described as the bottom-half of the surface of a horn torus wherein the axis of rotational symmetry of said horn torus is the central axis shared by said outer and inner tubes.

3. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving a parabola in a three-dimensional space about an axis of rotation that intersects with said parabola and is parallel with the axis of symmetry of said parabola wherein said axis of rotation is the central axis shared by said outer and inner tubes.

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4. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving one branch of a hyperbola in a three-dimensional space about an axis that intersects with said hyperbola branch and is parallel with the axis of symmetry of said hyperbola branch, wherein said axis of rotation is the central axis shared by said outer and inner tubes.

5. The superheater element of claim 1 wherein said boiler has a burner end opposite an exhaust end and said superheater element extending within said boiler from the burner end to the exhaust end.

6. The superheater element of claim 1 wherein the wall of the inner tube is shaped and sized to maximize the thermal conductivity between the inner and outer tubes, giving consideration to the tube material, and the pressure and temperature of the superheated steam flowing through said inner and outer tubes.

7. The superheater element of claim 1 wherein said inner and outer tubes are fabricated from material selected from a group consisting of carbon steel, stainless steel, and steel comprising chromium, molybdenum, and manganese alloys.

8. The superheater element of claim 1 wherein said return is fabricated from erosion resistant material comprising heat treated high carbon alloy steels.

9. The superheater element of claim 1 wherein said return is fabricated from erosion resistant material comprising turbine blade material.

10. The superheater element of claim 5, wherein saturated steam introduced into said inlet manifold gains heat energy while traveling along the outer tube towards the exhaust end of said boiler, is directed into said inner tube by said return, and then loses heat energy to the saturated steam within said outer tube while traveling within said inner tube towards the burner end of said boiler before exiting the outlet manifold.

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11. A method for superheating steam using a superheater element inserted into the firetube of a firetube boiler, said boiler having a burner end opposite an exhaust end, comprising the steps of:

providing a superheater element having an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube;

and a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a-point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube introducing saturated steam into said inlet manifold of said element;

causing said steam to travel within the outer tube towards the exhaust end of said boiler while absorbing heat energy from heated firetube gasses through the wall of the outer tube;

directing said now superheated steam into said inner tube by means of said return;
causing said superheated steam to travel within the inner tube towards the burner end of said boiler while losing heat energy to said saturated steam in said outer tube through the wall of saki inner tube; and

causing said superheated steam to exit said outlet manifold.

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12. A method for retrofitting firetube boilers to superheat steam comprising the steps of:

(a) providing one or more superheater elements each comprising an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube and a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube;

(b) providing an existing firetube boiler; and

(c) inserting said superheater elements into one or more firetubes of the existing firetube boiler.

13. The method of claim 12 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently compared with before the retrofit, by reducing the heat loss from the superheated steam to the boiler.

14. A method for retrofitting firetube boilers to superheat steam comprising the steps of:

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(a) providing one or more superheater elements each comprising an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube; and

a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube;

(b) providing an existing firetube boiler;

(c) providing one or more choke thimbles;

(d) inserting said superheater elements into one or more firetubes of the existing firetube boiler; and

(e) inserting a choke thimble into each firetube of the existing firetube boiler.

15. The method for retrofitting firetube boilers to superheat steam of claim 14, wherein only some of the firetubes have superheater elements and choke thimbles are used on only the firetubes that do not have superheater elements.

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16. The method of claim 14 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently compared with before the retrofit, by reducing the heat loss from the superheated steam to the boiler.

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CLAIMS

1. A superheater element for superheating steam within a firetube of a firetube boiler comprising:

an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube; and

a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube.

2. A superheater element of claim 1 wherein said interior face of said return is described as the bottom-half of the surface of a horn torus wherein the axis of rotational symmetry of said horn torus is the central axis shared by said outer and inner tubes.

3. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving a parabola in a three-dimensional space about an axis of rotation that intersects with said parabola and is parallel with the axis of symmetry of said parabola wherein said axis of rotation is the central axis shared by said outer and inner tubes.

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4. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving one branch of a hyperbola in a three-dimensional space about an axis that intersects with said hyperbola branch and is parallel with the axis of symmetry of said hyperbola branch, wherein said axis of rotation is the central axis shared by said outer and inner tubes.

5. The superheater element of claim 1 wherein said boiler has a burner end opposite an exhaust end and said superheater element extending within said boiler from the burner end to the exhaust end.

6. The superheater element of claim 1 wherein the wall of the inner tube is shaped and sized to maximize the thermal conductivity between the inner and outer tubes, giving consideration to the tube material, and the pressure and temperature of the superheated steam flowing through said inner and outer tubes.

7. The superheater element of claim 1 wherein said inner and outer tubes are fabricated from material selected from a group consisting of carbon steel, stainless steel, and steel comprising chromium, molybdenum, and manganese alloys.

8. The superheater element of claim 1 wherein said return is fabricated from erosion resistant material comprising heat treated high carbon alloy steels.

9. The superheater element of claim 1 wherein said return is fabricated from erosion resistant material comprising turbine blade material.

10. The superheater element of claim 5, wherein saturated steam introduced into said inlet manifold gains heat energy while traveling along the outer tube towards the exhaust end of said boiler, is directed into said inner tube by said return, and then loses heat energy to the saturated steam within said outer tube while traveling within said inner tube towards the burner end of said boiler before exiting the outlet manifold.

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11. A method for superheating steam using a superheater element inserted into the firetube of a firetube boiler, said boiler having a burner end opposite an exhaust end, comprising the steps of:

providing a superheater element having an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube; and

a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube introducing saturated steam into said inlet manifold of said element;

causing said steam to travel within the outer tube towards the exhaust end of said boiler while absorbing heat energy from heated firetube gasses through a wall of the outer tube;

directing said now superheated steam into said inner tube by means of said return; causing said superheated steam to travel within the inner tube towards the burner end of said boiler while losing heat energy to said saturated steam in said outer tube through a wall of the inner tube; and

causing said superheated steam to exit said outlet manifold.

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12. A method for retrofitting firetube boilers to superheat steam comprising the steps of:

(a) providing one or more superheater elements each comprising an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube and a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube;

(b) providing an existing firetube boiler; and

(c) inserting said superheater elements into one or more firetubes of the existing firetube boiler.

13. The method of claim 12 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently compared with before the retrofit, by reducing the heat loss from the superheated steam to the boiler.

14. A method for retrofitting firetube boilers to superheat steam comprising the steps of:

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(a) providing one or more superheater elements each comprising an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube; and

a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube;

(b) providing an existing firetube boiler;

(c) providing one or more choke thimbles;

(d) inserting said superheater elements into one or more firetubes of the existing firetube boiler; and

(e) inserting a choke thimble into each firetube of the existing firetube boiler.

15. The method for retrofitting firetube boilers to superheat steam of claim 14, wherein only some of the firetubes have superheater elements and choke thimbles are used on only the firetubes that do not have superheater elements.

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16. The method of claim 14 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently compared with before the retrofit, by reducing the heat loss from the superheated steam to the boiler.

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AMENDED CLAIMS
received by the International Bureau on 20 August 2018 (20.08.18)

CLAIMS (AMENDED LISTING):

1. A superheater element for conducting superheated steam within a firetube of a firetube boiler comprising:

an outer tube concentric about an inner tube;

a return connecting said outer and inner tubes at one end;

an inlet manifold connected to the non-return end of said outer tube; and

an outlet manifold connected to the non-return end of said inner tube;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis shared by said outer and inner tubes, the point of said interior face that intersects said central axis is raised towards said inner tube along said central axis, and said interior face is described as the surface of revolution generated by revolving a curved line segment with an endpoint on said central axis in three-dimensional space about said central axis.

2. A superheater element of claim 1 wherein said interior face of said return is described as the bottom-half of the surface of a horn torus wherein the axis of rotational symmetry of said horn torus is the central axis shared by said outer and inner tubes.

3. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving a parabola in a three-dimensional space about an axis of rotation that intersects with said parabola and is parallel with the axis of symmetry of said parabola wherein said axis of rotation is the central axis shared by said outer and inner tubes.

4. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving one branch of a hyperbola in a three-dimensional space about an axis that intersects with said hyperbola branch and is parallel with the axis of symmetry of said hyperbola branch, wherein said axis of rotation is the central axis shared by said outer and inner tubes.

5. The superheater element of claim 1 wherein said boiler has a burner end opposite an exhaust end and said superheater element extending within said boiler from the burner end to the exhaust end.

6. The superheater element of claim 1 wherein the wall of the inner tube is shaped and sized to maximize the thermal conductivity between the inner and outer tubes, giving consideration to the tube material, and the pressure and temperature of the superheated steam flowing through said inner and outer tubes.

7. The superheater element of claim 1 wherein said inner and outer tubes are fabricated from material with high thermal conductivity characteristics.

8. The superheater element of claim 1 wherein said inner and outer tubes are fabricated from material selected from a group consisting of carbon steel, stainless steel, and steel comprising chromium, molybdenum, and manganese alloys.

9. The superheater element of claim 1 wherein said return is fabricated from a very hard erosion resistant material.

10. The superheater element of claim 9 wherein said return is fabricated from turbine blade material.

11. The superheater element of claim 1, wherein saturated steam introduced into said inlet manifold gains heat energy while traveling along the outer tube towards the burner end of said element, is directed into said inner tube by said return, and then loses heat energy to the saturated steam within said outer tube while traveling within said inner tube towards the exhaust end of said element before exiting the outlet manifold.

12. A firetube boiler for producing superheated steam comprising

(a) a cylindrical boiler shell;

(b) a burner;

(c) one or more firetubes carrying hot gases heated by said burner;

(d) tube sheets;

(e) one or more choke thimbles that control the flow of hot gases into the firetubes;

(f) one or more superheater elements comprising an outer tube concentric about an inner tube; a return connecting said outer and inner tubes at one end; and an outlet manifold connected to the non-return end of said inner tube;

(g) wherein the superheater elements are inserted into at least one firetube and positioned within said firetube such that the inlet and outlet manifolds are oriented away from the burner;

(h) wherein a choke thimble is inserted into each firetube; and

(i) wherein the hot gases from the burner superheat the saturated steam within the superheater element.

13. The firetube boiler of claim 12, wherein only some of the firetubes have superheater elements and choke thimbles are used on only the firetubes that do not have superheater elements.

14. The firetube boiler for producing superheated steam of claim 12 wherein superheater elements are used in more than one firetube.

15. The firetube boiler of claim 12, wherein said choke thimbles are fabricated from heat resistant materials.

16. The choke thimble element of claim 15, wherein said heat resistant material is ceramic.

17. A method for superheating steam using a superheater element inserted into the firetube of a firetube boiler, said boiler having a burner end opposite an exhaust end, comprising the steps of:

providing a superheater element having an outer tube concentric about an inner tube that extends within said boiler from the burner end to the exhaust end; a return connecting said outer and inner tubes at the burner end of said element, wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis shared by said outer and inner tubes, the point of said interior face that intersects said central axis is raised towards said inner tube along said central axis, and said interior face is described as the surface of revolution generated by revolving a curved line segment with an endpoint on said central axis in three-dimensional space about said central axis; an inlet manifold connected to the exhaust end of said outer tube; and an outlet manifold connected to the exhaust end of said inner tube;

introducing saturated steam into said inlet manifold of said element;

causing said steam to travel within the outer tube towards the burner end of said element while absorbing heat energy from heated firetube gasses through the wall of the outer tube;

directing said now superheated steam into said inner tube by means of said return;

causing said superheated steam to travel within the inner tube towards the exhaust end of said element while losing heat energy to said saturated steam in said outer tube through the wall of said inner tube; and

causing said superheated steam to exit said outlet manifold.

18. A method for superheating steam using a superheater element inserted into the firetube of a firetube boiler, said boiler having a burner end opposite an exhaust end, and with one or more choke thimbles that control the flow of hot gases into the firetubes comprising the steps of:

inserting a choke thimble into each firetube;

providing a superheater element having an outer tube concentric about an inner tube that extends within said boiler from the burner end to the exhaust end; a return connecting said outer and inner tubes at the burner end of said element; an inlet manifold connected to the exhaust end of said outer tube; and an outlet manifold connected to the exhaust end of said inner tube;

introducing saturated steam into said inlet manifold of said element;

causing said steam to travel within the outer tube towards the burner end of said element while absorbing heat energy from heated firetube gasses through the wall of the outer tube;

directing said now superheated steam into said inner tube by means of said return;

causing said superheated steam to travel within the inner tube towards the exhaust end of said element while losing heat energy to said saturated steam in said outer tube through the wall of said inner tube; and

causing said superheated steam to exit said outlet manifold.

19. The method for producing superheated steam of claim 18, wherein only some of the firetubes have superheater elements and choke thimbles are used on only the firetubes that do not have superheater elements.

20. The method for producing superheated steam of claim 18 wherein superheater elements are used in more than one firetube.

21. The method for producing superheated steam of claim 18, wherein said choke thimbles are fabricated from heat resistant materials.

22. The method for producing superheated steam of claim 21, wherein said heat resistant material is ceramic.

23. A method for retrofitting firetube boilers to superheat steam comprising the steps of:
(a) providing one or more superheater elements comprising an outer tube concentric about an inner tube; a return connecting said outer and inner tubes at one end, wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis shared by said outer and inner tubes, the point of said interior face that intersects said central axis is raised towards said inner tube along said central axis, and said interior face is described as the surface of revolution generated by revolving a curved line segment with an endpoint on said central axis in three-dimensional space about said central axis; an inlet manifold connected to the exhaust end of said outer tube; and an outlet manifold connected to the exhaust end of said inner tube;
(b) providing an existing firetube boiler; and
(c) inserting said superheater elements into one or more firetubes of the existing firetube boiler.

24. The method of claim 23 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently.

25. A method for retrofitting firetube boilers to superheat steam comprising the steps of:
(a) providing one or more superheater elements comprising an outer tube concentric about an inner tube; a return connecting said outer and inner tubes at one end; an inlet manifold connected to the exhaust end of said outer tube; and an outlet manifold connected to the exhaust end of said inner tube;
(b) providing an existing firetube boiler;
(c) providing one or more choke thimbles;
(d) inserting said superheater elements into one or more firetubes of the existing firetube boiler; and
(e) inserting a choke thimble into each firetube of the existing firetube boiler.

26. The method for retrofitting firetube boilers to superheat steam of claim 25, wherein only some of the firetubes have superheater elements and choke thimbles are used on only the firetubes that do not have superheater elements.

27. The method of claim 25 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently.

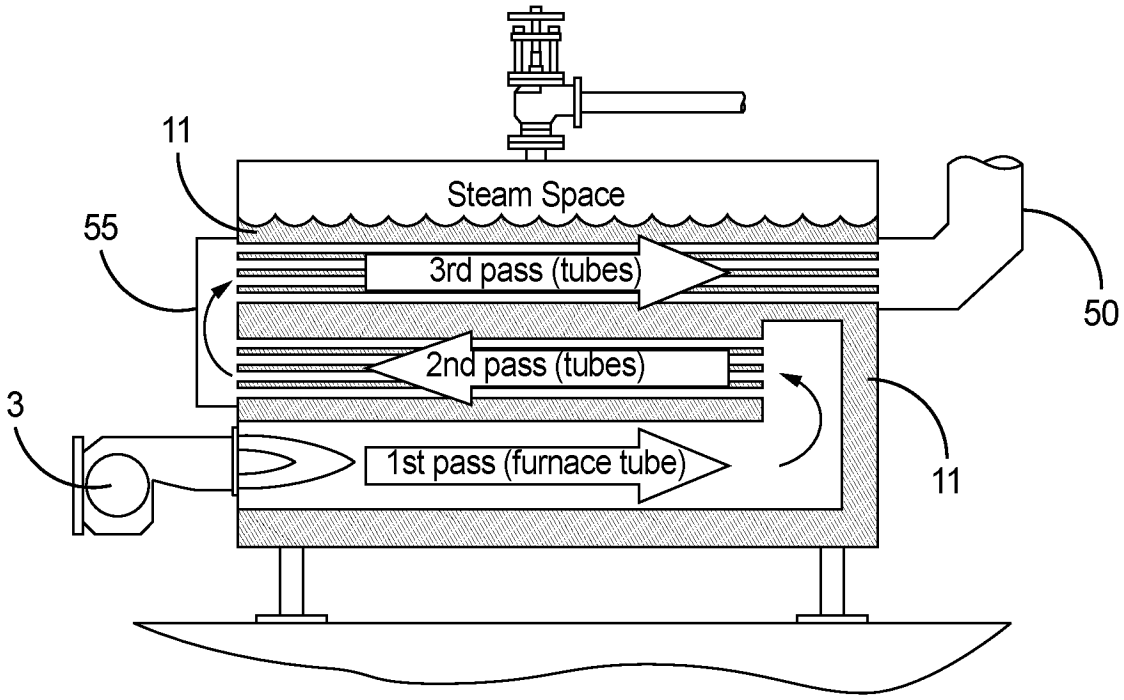

11
Steam Space
55
3rd pass (tubes)
50
2nd pass (tubes)
3
1st pass (furnace tube)
11

FIG. 1A

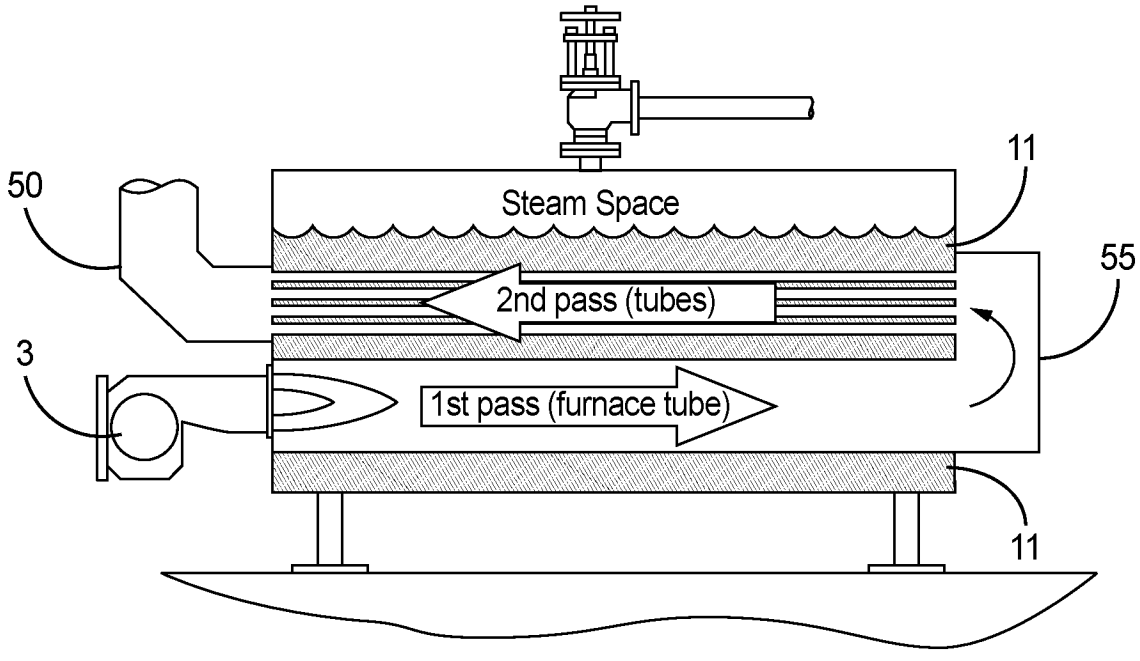

11
50
Steam Space
55
2nd pass (tubes)
3
1st pass (furnace tube)
11

FIG. 1B

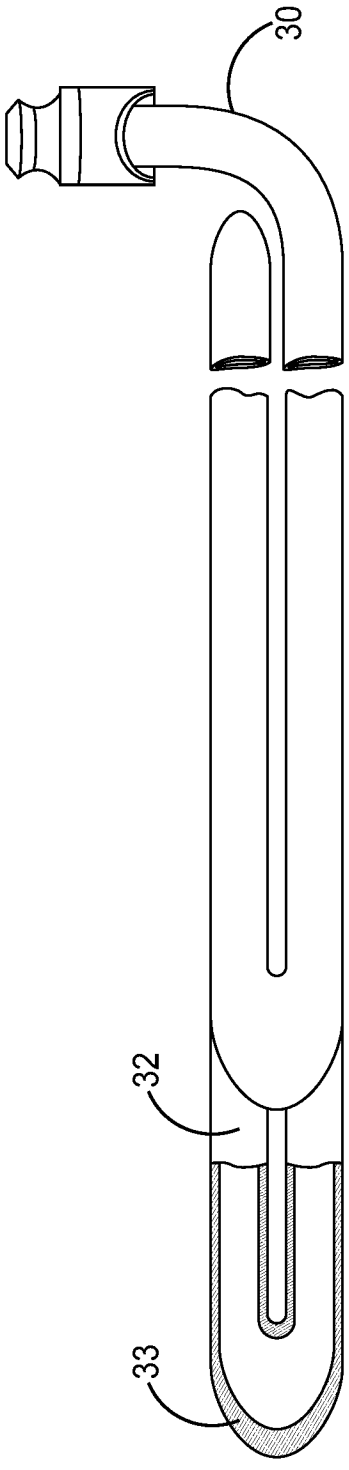

30
32
33

FIG. 2A

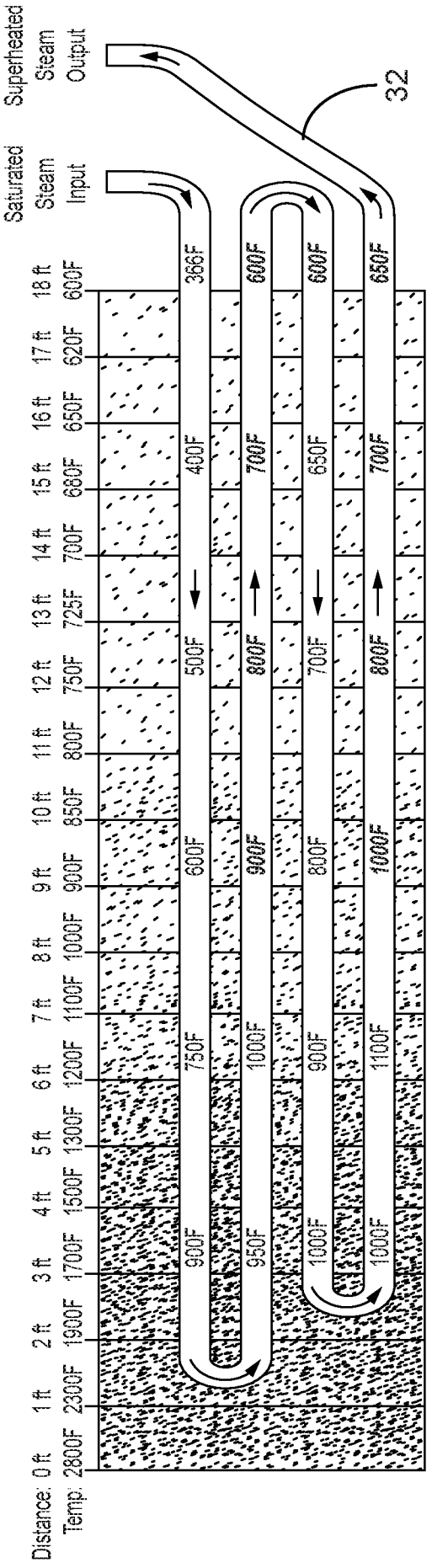

Superheated Steam Output
Saturated Steam Input
32
Distance: 0 ft 1 ft 2 ft 3 ft 4 ft 5 ft 6 ft 7 ft 8 ft 9 ft 10 ft 11 ft 12 ft 13 ft 14 ft 15 ft 16 ft 17 ft 18 ft
Temp: 2800F 2300F 1900F 1700F 1500F 1300F 1200F 1100F 1000F 900F 850F 800F 750F 725F 700F 680F 650F 620F 600F
366F
400F
500F
600F
750F
900F
950F
1000F
700F
650F
800F
900F
1000F
1100F
1000F
1000F
800F
700F
600F
800F
700F
600F
650F

FIG. 2B

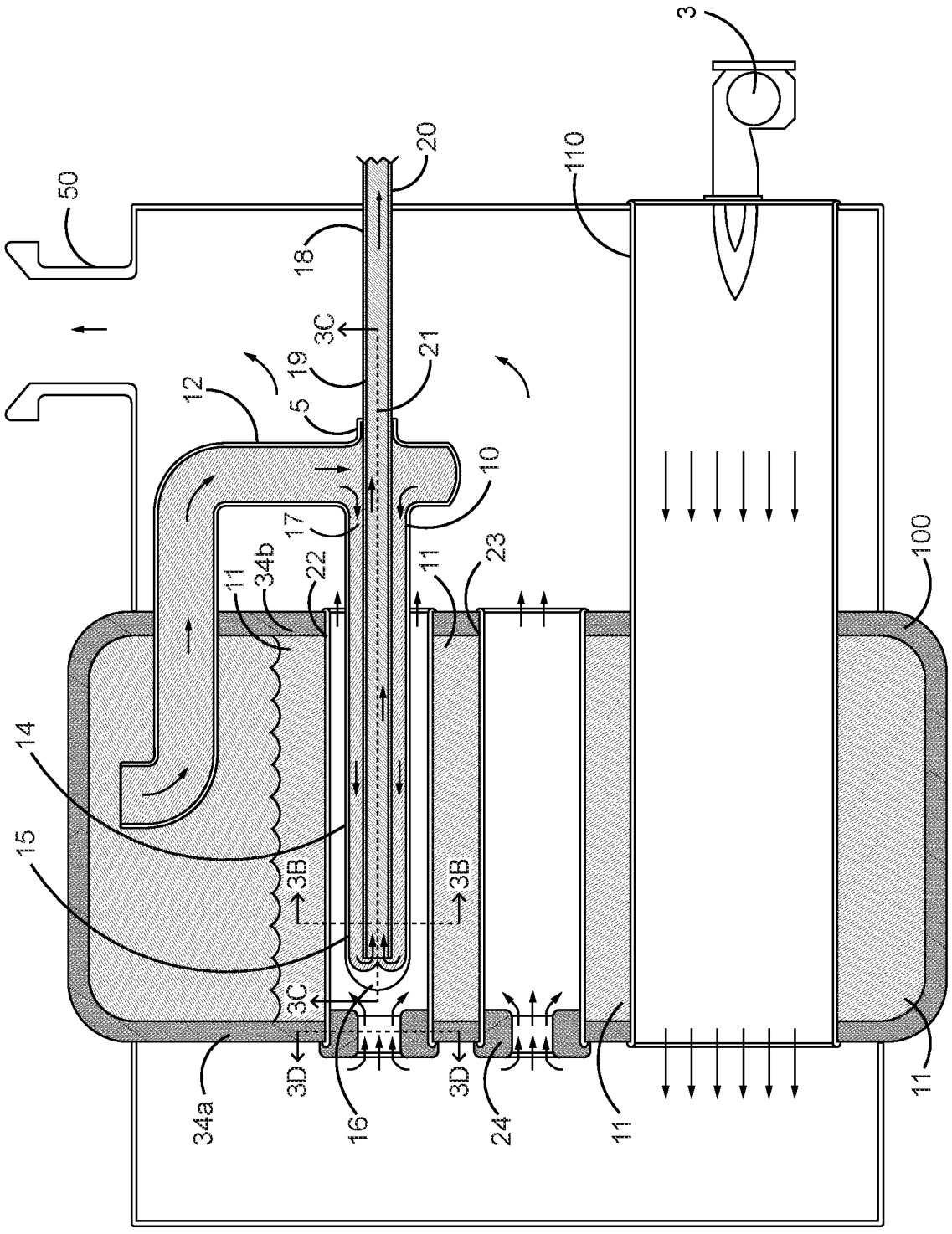

3
20
110
50
18
3C
19
21
12
5
10
17
34b
22
11
23
100
14
15
3B
3B
3C
3D
3D
34a
16
24
11
11

FIG. 3A

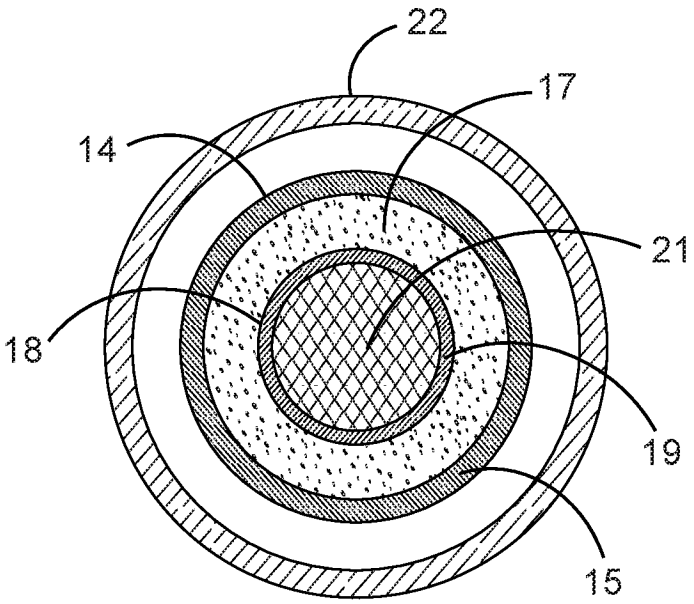


FIG. 3B

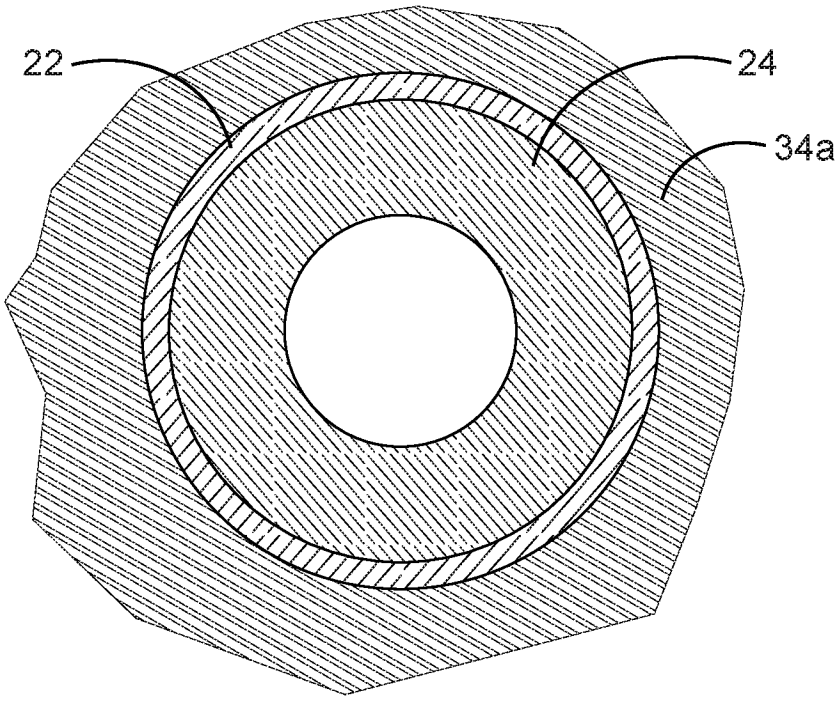


FIG. 3D

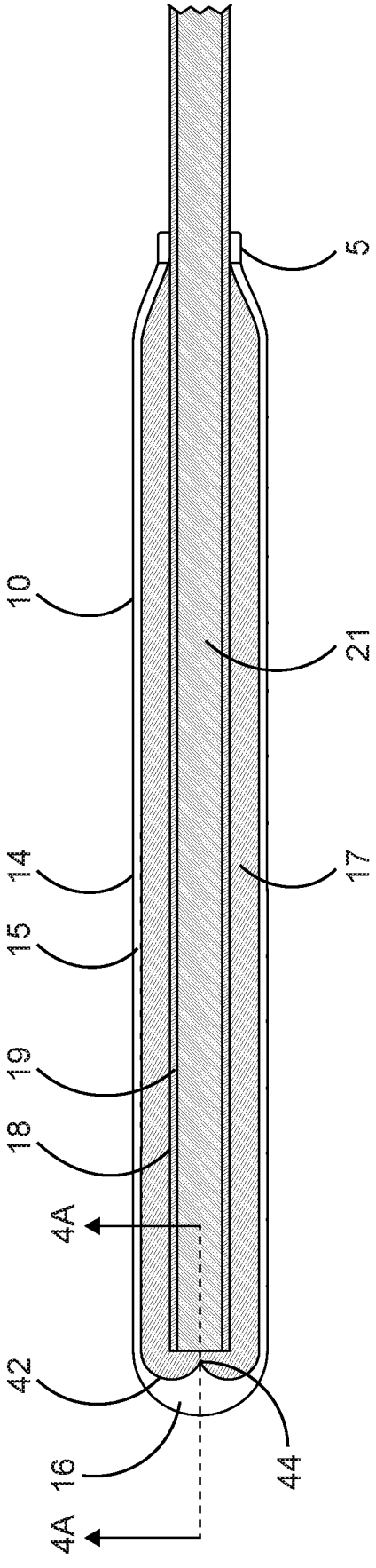


FIG. 3C

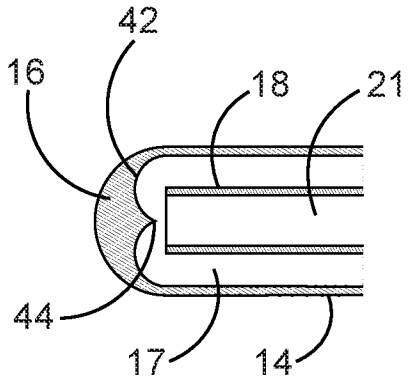


FIG. 4A

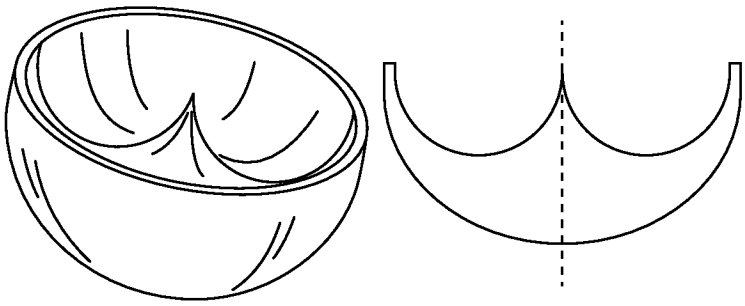


FIG. 4B

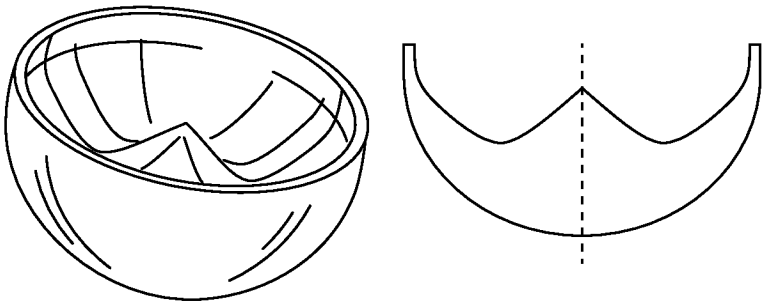


FIG. 4C

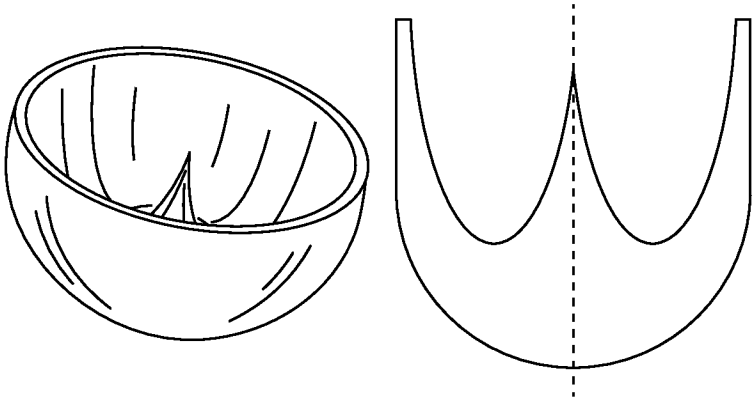
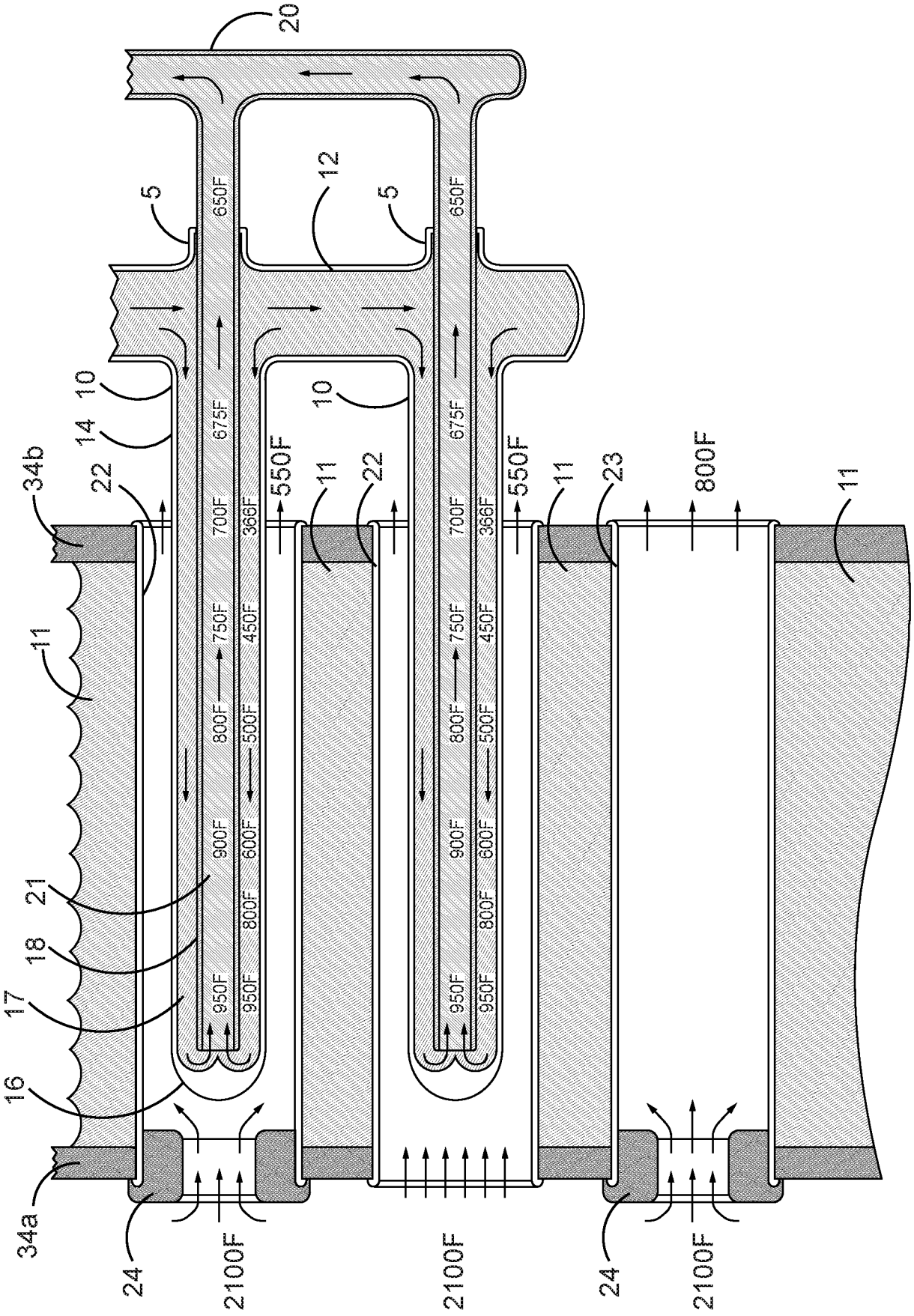


FIG. 4D


20
5
12
5
650F
650F
10
10
14
675F
675F
550F
550F
34b
22
700F
700F
366F
366F
11
22
11
23
800F
11
750F
750F
450F
450F
800F
800F
500F
500F
900F
900F
600F
600F
21
800F
800F
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950F
950F
950F
950F
17
16
34a
24
2100F
2100F
24
2100F

FIG. 5

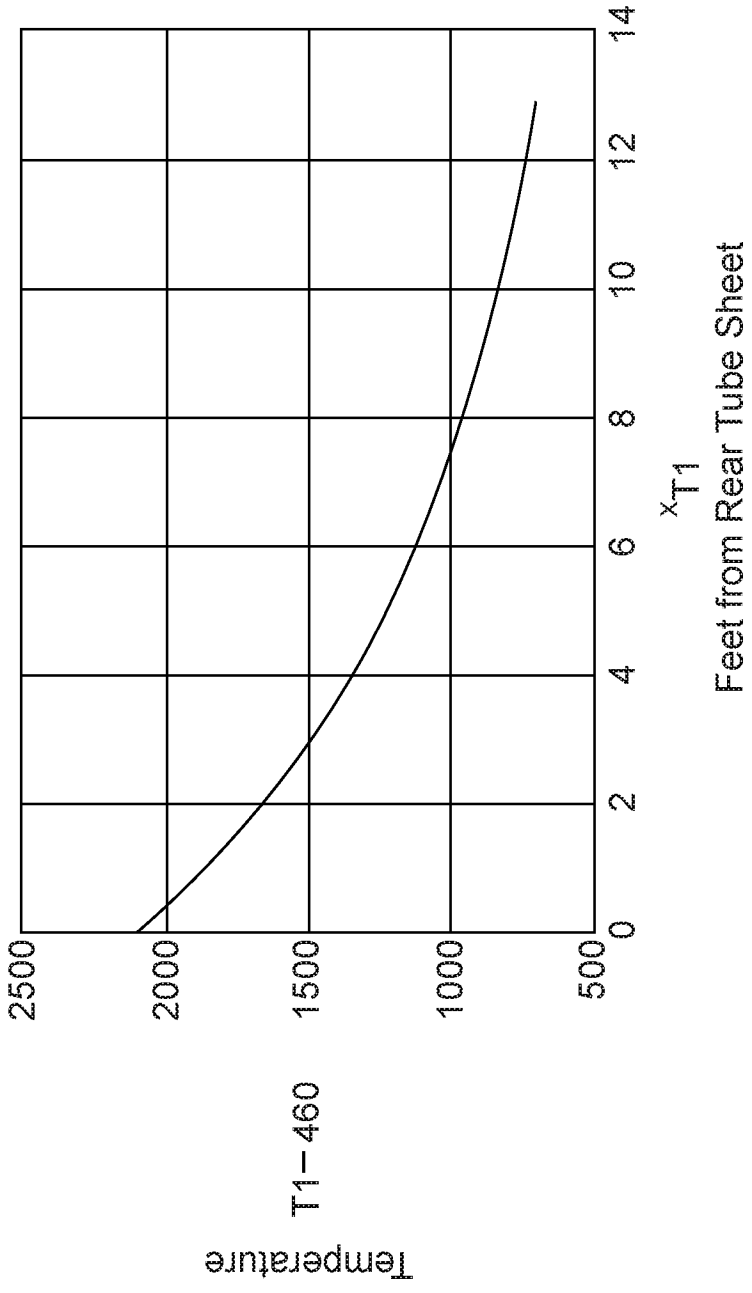
Temperature
T1 – 460
2500
2000
1500
1000
500
0
2
4
6
8
10
12
14
x_{T1}
Feet from Rear Tube Sheet

FIG. 6

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 June 2018 (21.06.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/111730 A4

(51) International Patent Classification:
F22G 7/02 (2006.01)

(21) International Application Number:
PCT/US2017/065485

(22) International Filing Date:
09 December 2017 (09.12.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
15/381,682 16 December 2016 (16.12.2016) US

(72) Inventor; and
(71) Applicant: **AUSTIN, James Matthew** [US/US]; 47-371A Kapehe Street, Kaneohe, Hawaii 96744 (US).

(74) Agent: **REISS, Seth M**; Seth M Reiss, AAL, ALLLC, 3770 Lurline Drive, Honolulu, Hawaii 96816 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS

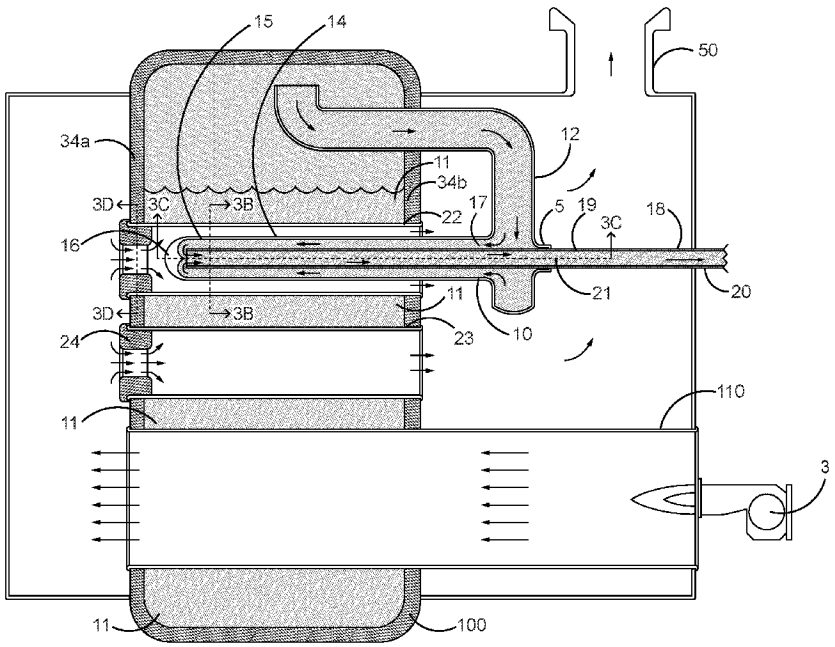

FIG. 3A

(57) Abstract: An annular superheater element (10) for superheating steam within firetubes (22) of firetube boilers comprising concentric inner and outer tubes and a specially designed return end cap (16). Saturated steam introduced into the outer tube (14) of said superheater element is superheated while traveling towards the burner end of the tube, is directed into the inner tube (18) by means of the return end cap (16), and travels away from the burner side of the element (10) where it is exhausted for use as superheated steam. While traversing the inner tube, the superheated steam gives off heat energy through the wall of the inner tube to the steam traveling in the outer tube towards the burner end of the tube, conserving energy. The improved superheater element produces superheated steam more efficiently, with less fuel, and steam capable of doing more work, than conventional superheater elements and can be used to retrofit existing firetube type boilers.

WO 2018/111730 A4

[Continued on next page]

WO 2018/111730 A4

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*
— *with amended claims (Art. 19(1))*

(88) Date of publication of the international search report:
02 August 2018 (02.08.2018)

Date of publication of the amended claims:
04 October 2018 (04.10.2018)

MLT AIKINS

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Scott E. Davidson
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403.693.4308

Patent Assistant:
Mary Lou Aswit
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306-347-8617

June 25, 2019

BY FAX

Commissioner of Patents,
Canadian Intellectual Property Office
Place du Portage I
50 Victoria Street
Ottawa- Gatineau, Canada
K1A 0C9

Dear Sirs:

Re: **New Canadian PCT Nationalization of International Application No. PCT/US2017/065485**
Title: **ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS**
Applicant: **James Matthew Austin**
Entity: **Small**
Our file: **0141988-00001**

On behalf of the Applicant we wish to effect the national entry of the above captioned PCT application before the Canadian office. Under Section 58(3)(b) of the Patent Rules we are requesting entry of the PCT application within the 42 month period after the priority date and are authorizing payment of the additional fee for late payment under item 11 of the Schedule II of the Patent Rules.

In support of this national stage entry, please find enclosed the following documents and requirements:

a) Request for National Stage Entry;
b) Cover page of the PCT application;
c) Declaration of Entitlement; and
d) CIPO Fee Payment Form.

You are authorized to charge the fees outlined below to our CIPO Deposit Account No. 600000786 or credit card in accordance with the attached Fee Payment Form:

Fee:	Patent application fee
Entity status:	Small
Amount:	$200.00

Fee:	Late Entry Fee
Amount:	$200.00

Fee:	Maintenance fee – Second Anniversary
Amount:	$50.00

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If you have any questions or issues in respect of this payment, please feel free to contact us at the coordinates outlined above.

We look forward to receipt of the filing receipt in due course. Thank you in advance for your assistance in this regard.

Yours very truly,

MLT AIKINS LLP
AGENT NO. 10904

Scott E. Davidson

/rmc
Encl.

Applicant's File: 0141988-00001

IN THE CANADIAN INTELLECTUAL PROPERTY OFFICE

Request for Entry into National Phase **Articles 22 or 39 of the *Patent Cooperation Treaty***
International Application No. PCT/US2017/065485 **International Filing Date: December 9, 2017**
Applicant(s): **James Matthew Austin**
Entity status: **Small**
Title : **ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS**

1. The above-identified Applicant, **James Matthew Austin,** whose address is:

   47-371A Kapehe Street,
   Kaneohe, Hawaii 96744
   United States

   Owns the entire right in Canada to an invention entitled **"ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS"** which is described and claimed in the international application and any amendments thereto.

2. The inventors are:

   James Matthew Austin
   47-371A Kapehe Street,
   Kaneohe, Hawaii 96744
   United States

3. The Applicant claims priority protection in relation to the following prior filed applications:

   United States
   Filed December 16, 2016
   Ser. No. 15/381682

4. The Applicant appoints MLT AIKINS LLP, 1500 – 1874 Scarth Street, Regina, Saskatchewan, Canada S4P 4E9 as:

   (a) their representative for service of any proceedings taken under the Patent Act; and

   (b) their agent with full power to appoint an associate agent when required to do so by Section 144 of the Patent Rules and to revoke such appointment, to sign this request and drawings, to amend the specification and drawings, to prosecute the application and to receive the patent granted on said application, and the applicant hereby ratifies any act done by the said appointees in respect of the said application.

5. **The Applicant believes that in accordance with subsection 3.01(2) of the Patent Rules the Applicant is entitled to pay fees at the small entity level.**

6. The applicant accordingly hereby requests commencement of national phase procedures consequent to the designation of Canada in such international application and prays that a patent may be granted to them for the said invention.

SIGNED at Regina, Saskatchewan, Canada this June 25, 2019.

James Matthew Austin

MLT Aikins LLP

MLT AIKINS LLP
Agent No. 10904
Agents for the Applicants

MLT AIKINS

Applicant's File: 0141988-00001

IN THE CANADIAN INTELLECTUAL PROPERTY OFFICE

DECLARATION OF ENTITLEMENT

Filed at time of filing of application

Title :
ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS

The Inventor(s) are:

James Matthew Austin
47-371A Kapehe Street,
Kaneohe, Hawaii
United States 96744

The Applicant(s) are the inventors.

SIGNED at Regina, Saskatchewan, Canada this June 25, 2019.

James Matthew Austin

MLT Aikins LLP

MLT AIKINS LLP
AGENT NO. 10904
Agents for the Applicants

MLT AIKINS

MLT AIKINS

WESTERN CANADA'S LAW FIRM

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2020/11/24

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OPIC-CIPO C005856309

#4612823

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fh

MLT Aikins LLP
1500 - 1874 Scarth Street
Regina, Saskatchewan S4P 4E9
T: (306) 975-7100
F: (306) 352-5250

November 24, 2020

BY FAX

Scott E. Davidson
sdavidson@mltaikins.com
403.693.4308

Maintenance Fee Assistant
Jocelyn Sanchez
(604)608-4565
jsanchez@mltaikins.com

Commissioner of Patents
Canadian Intellectual Property Office
Place du Portage I
50 Victoria Street, Room C-114
Gatineau, Canada
K1A 0C9

Attn: Maintenance Fees

Dear Sir:

Re:	**Canadian Patent Application Ser. No. 3048401**
Title:	**ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS**
Owner:	**James Matthew Austin**
Our File:	**0141988-00001 Entity Status: Small**

We wish to proceed with the payment of the following maintenance fee in respect of the above-captioned case:

Anniversary:	3
Due date:	December 9, 2020
Amount:	50.00

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If you have any questions or issues in respect of this payment, please feel free to contact Jocelyn Sanchez by telephone at (604)608-4565, or by email at jsanchez@mltaikins.com.

All of which is respectfully submitted.

Very truly yours,

MLT AIKINS LLP
AGENT NO. 10904

MLT Aikins LLP

Patent Branch Maintenance Fee Calculation Sheet

Date: November 24, 2020 **Listing #** 3048401

Name, complete mailing address and telephone number of the person and company paying the fee:
Scott Davidson
MLT AIKINS LLP
1500-1874 Scarth Street,
Regina, Saskatchewan, S4P 4E9
(306) 347-8000

Patent application or patent #	Reference #	Anniversary	Maintenance fee ($)	Small entity	Reinstatement fee ($)	Late fees ($)	Total
3048401	0141988-00001	3	50.00	Small			$50.00

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☐ ____ Additional sheets attached for listing additional patent applications or patents

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Deposit account No.: 600000786

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Signature: MLT Aikins LLP

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Canada

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MLT Aikins LLP
1500 - 1874 Scarth Street
Regina, Saskatchewan S4P 4E9
T: (306) 975-7100
F: (306) 352-5250

ISDE-ISED Canada AAAA/MM/JJ-YYYY/MM/DD
2021/11/12
319 - 21
OPIC-CIPO C006023809

November 12, 2021

BY FAX

6230651

Scott E. Davidson
sdavidson@mltaikins.com
403.693.4308

Maintenance Fee Assistant
Jocelyn Sanchez
(604)608-4565
jsanchez@mltaikins.com

Commissioner of Patents
Canadian Intellectual Property Office
Place du Portage I
50 Victoria Street, Room C-114
Gatineau, Canada
K1A 0C9

Attn: Maintenance Fees

Dear Sir:

Re: Canadian Patent Application Ser. No. 3048401
Title: ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS
Owner: James Matthew Austin
Our File: 0141988-00001 Entity Status: Small

We wish to proceed with the payment of the following maintenance fee in respect of the above-captioned case:

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If you have any questions or issues in respect of this payment, please feel free to contact Jocelyn Sanchez by telephone at (604)608-4565, or by email at jsanchez@mltaikins.com.

All of which is respectfully submitted.

Very truly yours,

MLT AIKINS LLP

SCOTT E. DAVIDSON
AGENT NO. 11495

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MLT AIKINS LLP
1500-1874 Scarth Street,
Regina, Saskatchewan, S4P 4E9
(306) 347-8000

Patent application or patent #	Reference #	Anniversary	Maintenance fee ($)	Small entity	Reinstatement fee ($)	Late fees ($)	Total
3048401	0141988-00001	4	50.00	Small			$50.00

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Deposit account No.: 600000786

Name: Scott Davidson

Signature: Scott Davidson

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Canada

Date Reçue/Date Received 2021-11-12

CA 03048401 2019-06-25

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference 5636-1PCT	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2017/065485	International filing date *(day/month/year)* 09 December 2017 (09.12.2017)	Priority date *(day/month/year)* 16 December 2016 (16.12.2016)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant AUSTIN, James Matthew		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 15 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☒	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 18 June 2019 (18.06.2019)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Athina Nickitas-Etienne e-mail: pct.team4@wipo.int

CA 03048401 2019-06-25

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: SETH M. REISS
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PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)* 20 JUN 2018

Applicant's or agent's file reference
5636-1PCT

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US 17/65485	09 December 2017 (09.12.2017)	16 December 2016 (16.12.2016)

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - F22G 7/02 (2018.01)
CPC - F22G 7/02; F22 G 1/005; F22G 3/005; F22G 3/006; F22B 9/00; F22B 13/00; F22B 31/00; F22B 31/08; F22B 37/06

Applicant AUSTIN, JAMES MATTHEW

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	24 May 2018	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 17/65485

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

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Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-19	YES
	Claims	None	NO
Inventive step (IS)	Claims	16, 17	YES
	Claims	1-15, 18, 19	NO
Industrial applicability (IA)	Claims	1-19	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1, 2 and 6 lacks an inventive step under PCT Article 33(3) as being obvious over GB 24,407 A (BOLTON) in view of GB 18,144 A to STENNING et al. (hereinafter 'STENNING').

As per claim 1, BOLTON discloses a superheater element for conducting superheated steam within a firetube of a firetube boiler (This invention relates to apparatus employed for superheating steam. Heretofore superheaters have been proposed in which Field tubes forming the superheater elements are placed within the fire tubes of the steam generator, pg 2, ln 5-7 - the steam generator is considered to be a boiler) comprising: an outer tube concentric about an inner tube (Within the ends of the fire tubes a, see Figures 1 and 2, and from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d. Each of the latter is divided into two compartments e, f by a partition g into which are expanded or otherwise secured open ended tubes h projecting within the tubes c before referred to, Fig 1, 2; pg 2, ln 20-25 - as can be seen in Fig 1, outer tube c is an outer tube concentric with inner tube h); a return connecting said outer and inner tubes at one end (from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d, Fig 1, 2; pg 2, ln 20-22; the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1; pg 2, ln 26-30 - the semi-spherical closed end of tube c is clearly shown in Fig 1 to return saturated steam that has gone through tube c into tube h to be returned to header d, which return is considered to fluidly connect the outer and inner tubes at one end, which fluid connection is the same as the connection of the outer and inner tubes as disclosed in applicantLs disclosure, which is a fluid connection only as most clearly shown in Fig 4A of applicantLs disclosure; thus the closed end of tube c is considered to be a return connecting said outer and inner tubes at one end); an inlet manifold connected to the non-return end of said outer tube (In the arrangement illustrated at Figures 3 and 4, the header or distribution box d is divided into three compartments e, f and p. The saturated steam from the supply pipe i flows first to the compartment e, then by way of the tubes c and h to the compartment f, similarly to the compartment p and finally to the superheated steam supply pipe or outlet o by way of the branch pipe n, Fig 3, 4; pg 2, ln 37-41 - the plate at the side of compartment e which receives saturated steam from supply pipe i which then flows into the non-return end of outer tube c through openings in the plate that receive the non-return end of outer tube c is considered to be an inlet manifold connected to the non-return end of said outer tube); and an outlet manifold connected to the non-return end of said inner tube (In the arrangement illustrated at Figures 3 and 4, the header or distribution box d is divided into three compartments e, f and p. The saturated steam from the supply pipe i flows first to the compartment e, then by way of the tubes c and h to the compartment f, similarly to the compartment p and finally to the superheated steam supply pipe or outlet o by way of the branch pipe n, Fig 3, 4; pg 2, ln 37-41 - the plate at the side of compartment e which receives saturated steam from the non-return end of inner tube h through openings in the plate that receive the non-return end of inner tube h which steam then flows into compartment f to flow to outlet o is considered to be an outlet manifold connected to the non-return end of said inner tube). BOLTON does not disclose the return at the end of tube c as being a separate element from the outer tube. STENNING discloses a superheater element of a steam superheater including co-axial tubular portions and an end cap attached to the tubular portions forming the return of on the end of the tubular portions (To these ends, the invention consists in a superheater element comprising co-axial tubular portions secured together at the ends to leave an annular duct, one end of which is provided with an inlet for the saturated steam and the other end with an outlet for the superheated steam, pg 1, para 5, ln 1-4; According to one specific form, the heater element is connected to the superheated steam pipe, k, referred to, by way of a return bend, m, of U form, lying beyond the operative length of the annulus, the ends of the U-legs, n, n, being united symmetrically with the annular heating space at diametrically opposite points, i, i, as shown, while the bend of the U at its centre is provided with a third leg, n.sup.1, which may be welded or otherwise secured to the superheated steam pipe, k, itself. Any other appropriate form of union may, however, be used. Into the annular space between the co-axial tubes, c and d, Fig 1-3; pg 4, para 2, ln 1-8; para 3, ln 1). In view of STENNING, it would have been obvious to one of ordinary skill in the art to have made the return of BOLTON in the form of a separate end cap from the end of outer tube c so as to have simplified the forming and construction of the tubing and end cap.

As per claim 2, BOLTON in view of STENNING render obvious the superheater element of claim 1 and BOLTON further shows in Fig 1 wherein said return has a concave inner surface that is rotationally symmetric at all angles of rotation and wherein the center of said inner surface extends towards said inner tube (considering center to be the area forming the central portion, as for example the center of a room, the center of the inner surface of the return of BOLTON is considered to extend towards the inner tube c as it extends radially inwardly from the outer perimeter of the return towards the inner tube).

-- Please see Supplemental Box --

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.

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Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Claims 12 and 19 have the following defects in the form or contents thereof: in claim 12, in line 6 thereof, the recitation "an existing firetube boilers" in step (b), within the context of the method step in step (c) of "inserting said superheater element into one or more firetubes of the existing firetube boiler", should apparently be "an existing firetube boiler" in line 6 and has been interpreted as such in this written opinion. In claim 19, which is stated as dependent on claim 14, the recitation of "said heat resistant material is ceramic" only finds antecedent basis in the recitation of "heat resistant materials" in claim 18. Thus, claim 19 has been interpreted as dependent on claim 18 in this written opinion.

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of:
Box No. V.2. Citations and explanations:

As per claim 6, BOLTON in view of STENNING render obvious the superheater element of claim 1, but do not disclose wherein the wall of the inner tube is shaped and sized to maximize the thermal conductivity between the inner and outer tube, giving consideration to the tube material, and the pressure and temperature of the superheated steam flowing through said inner and outer tubes. However, such choices of the shape and size of the wall of the inner tube so as to maximize the thermal conductivity between the inner and outer tube, giving consideration to the tube material, and the pressure and temperature of the superheated steam flowing through said inner and outer tubes would have been obvious to one of ordinary skill in the art as routine matters of choice in making conventional engineering decisions of shape and size for the superheater element of BOLTON to optimize the performance of the superheater.

Claims 3 and 4 lack an inventive step under PCT Article 33(3) as being obvious over BOLTON in view of STENNING and further in view of US 2009/0266529 A1 (JAHIER).

As per claim 3, BOLTON in view of STENNING render obvious the superheater element of claim 1, but do not further disclose wherein said inner and outer tubes are fabricated from material with high thermal conductivity characteristics. JAHIER discloses carbon steel pipe for boilers with high efficency heat transfer properties (The present invention relates to a protected carbon steel pipe for fire tube heat exchange devices, particularly boilers, para [0001]; thus provide, as in the previously described variations, optimum conditions both as regards the protection of the pipe 38 against corrosion and for high efficiency in heat transfer from the flue gases contained in the pipe 38 to the water to be heated, para [0033]). In view of JAHIER, it would have been obvious to one of ordinary skill in the art to have provided for the superheater element of BOLTON wherein said inner and outer tubes were fabricated from material with high thermal conductivity characteristics, so as to have optimized the superheating efficiency of the superheater element.

As per claim 4, BOLTON in view of STENNING render obvious the superheater element of claim 1, but do not further disclose wherein said inner tube is fabricated from material selected from a group comprising of carbon steel, stainless steel, and steel comprising chromium, molybdenum, and manganese alloys. JAHIER discloses carbon steel pipe for boilers to ensure optimum quality of welded joints (The present invention relates to a protected carbon steel pipe for fire tube heat exchange devices, particularly boilers, para [0001]; The pipes comprised within said devices are made of carbon steel in order to ensure optimum quality of the welded joints between the pipes and the structures of the devices, which are also made of carbon steel, para [0003]). In view of JAHIER, it would have been obvious to one of ordinary skill in the art to have provided for the superheater element of BOLTON wherein said inner tube were fabricated from carbon steel, which is a material selected from a group comprising of carbon steel, stainless steel, and steel comprising chromium, molybdenum, and manganese alloys, so as to have ensured optimum quality of the welded joints between the pipes and the structures of the devices.

Claim 5 lacks an inventive step under PCT Article 33(3) as being obvious over BOLTON in view of STENNING and further in view of US 5,207,776 A (PEARCE).

As per claim 5, BOLTON in view of STENNING render obvious the superheater element of claim 1, but do not further disclose wherein said return is fabricated from a high carbon alloy steel encased within boiler code compliant materials. PEARCE discloses tubing for a boiler that in order to meet mandatory boiler codes including carbon steel clad on the outside (i.e. encased) with a cladding alloy (A combination of suitable corrosion resistance and mechanical properties is often required, col 1, ln 24-25; Bi-metallic tubes produced by the aforementioned hot coextrusion process have performed satisfactorily; their major drawback is their relatively high cost. Generally, a low-alloy steel tube with a 2-3 mm cladding of, for example, type 310 stainless steel, costs 7-9 times as much as a low-alloy steel tube, and as much or more than a monolithic tube made of the cladding alloy. Again, certain requirements such as operating conditions and various mandatory boiler codes and the like may prohibit the use of a corrosion resistant monolithic tube made of certain materials in a given environment, col 1, ln 57-67; it has become desirable to develop a new bi-metallic extrusion billet preform that can be utilized in the prior art hot coextrusion processes but which can be produced at a much lower cost than in the prior art method, col 2, ln 6-10). In view of PEARCE, it would have been obvious to one of ordinary skill in the art to have fabricated the return of BOLTON from carbon alloy steel encased within boiler code compliant materials, so as to have enabled the return to better be able to withstand the heat that would have been applied to the return in the supeheating process. To make such an alloy a high carbon alloy would have been obvious to one of ordinary skill in the art, so as to have made the return stronger and better able to withstand high temperatures.

-- Please see next Supplemental Box --

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Box No. V.2. Citations and explanations:

Claims 7-13 lack an inventive step under PCT Article 33(3) as being obvious over BOLTON in view of STENNING and US 1,495,759 A to MILNE et al. (hereinafter 'MILNE').

As per claim 7, BOLTON discloses a superheater element for superheating saturated steam within a firetube of a firetube boiler (This invention relates to apparatus employed for superheating steam. Heretofore superheaters have been proposed in which Field tubes forming the superheater elements are placed within the fire tubes of the steam generator, pg 2, ln 5-7 - the steam generator is considered to be a boiler), comprising: an outer tube concentric about an inner tube (Within the ends of the tire tubes a, see Figures 1 and 2, and from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d. Each of the latter Is divided into two compartments e, f by a partition g into which are expanded or otherwise secured open ended tubes h projecting within the tubes c before referred to, Fig 1, 2; pg 2, ln 20-25 - as can be seen in Fig 1, outer tube c is an outer tube concentric with inner tube h); a return connecting said outer and inner tubes at one end (from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d, Fig 1, 2; pg 2, ln 20-22; the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1; pg 2, ln 26-30 - the semi-spherical closed end of tube c is clearly shown in Fig 1 to return saturated steam that has gone through tube c into tube h to be returned to header d, which return is considered to fluidly connect the outer and inner tubes at one end, which fluid connection is the same type of connection as the connection of the outer and inner tubes as disclosed in applicantLs disclosure, which is a fluid connection only as most clearly shown in Fig 4A of applicantLs disclosure); an inlet manifold connected to the exhaust end of said outer tube (In the arrangement illustrated at Figures 3 and 4, the header or distribution box d is divided into three compartments e, f and p. The saturated steam from the supply pipe i flows first to the compartment e, then by way of the tubes c and h to the compartment f, similarly to the compartment p and finally to the superheated steam supply pipe or outlet o by way of the branch pipe n, Fig 3, 4; pg 2, ln 37-41 - the plate at the side of compartment e which receives saturated steam from supply pipe i which then flows into the open end of outer tube c through openings in the plate that receive the open end of outer tube c is considered to be an inlet manifold connected to the exhaust end of said outer tube); and an outlet manifold connected to the non-return end of said inner tube (In the arrangement illustrated at Figures 3 and 4, the header or distribution box d is divided into three compartments e, f and p. The saturated steam from the supply pipe i flows first to the compartment e, then by way of the tubes c and h to the compartment f, similarly to the compartment p and finally to the superheated steam supply pipe or outlet o by way of the branch pipe n, Fig 3, 4; pg 2, ln 37-41 - plate at the side of compartment e which receives saturated steam from the non-return end of inner tube h through openings in the plate that receive the non-return end of inner tube h which steam then flows into compartment f to flow to outlet o is considered to be an outlet manifold connected to the non-return end of said inner tube). BOLTON does not disclose the return at the end of tube c as being a separate element from the outer tube; said boiler having a burner end opposite an exhaust end; said tubes extending within said boiler from the burner end to the exhaust end; the return connecting said outer and inner tubes at the burner end of said element. As for the return, STENNING discloses a superheater element of a steam superheater including co-axial tubular portions and an end cap attached to the tubular portions forming the return of on the end of the tubular portions (To these ends, the invention consists in a superheater element comprising co-axial tubular portions secured together at the ends to leave an annular duct, one end of which is provided with an inlet for the saturated steam and the other end with an outlet for the superheated steam, pg 1, para 5, ln 1-4; According to one specific form, the heater element is connected to the superheated steam pipe, k, referred to, by way of a return bend, m, of U form, lying beyond the operative length of the annulus, the ends of the U-legs, n, n, being united symmetrically with the annular heating space at diametrically opposite points, i, i, as shown, while the bend of the U at its centre is provided with a third leg, n.sup.1, which may be welded or otherwise secured to the superheated steam pipe, k, itself. Any other appropriate form of union may, however, be used. Into the annular space between the co-axial tubes, c and d, Fig 1-3; pg 4, para 2, ln 1-8; para 3, ln 1). In view of STENNING, it would have been obvious to one of ordinary skill in the art to have made the return of BOLTON in the form of a separate end cap from the outer tube c so as to have simplified the forming and construction of the tubing and end cap. As for said boiler having a burner end opposite an exhaust end; said tubes extending within said boiler from the burner end to the exhaust end; the return connecting said outer and inner tubes at the burner end of said element, MILNE discloses a superheater element within a fire tube (a novel manner of collocating each superheater element with respect to its inclosing standard fire tube, pg 1, ln 79-81) where the boiler has a burner end opposite an exhaust end with outer and inner tubes of the superheater extending within said boiler from the burner end to the exhaust end with tubes extending within said boiler from the burner end to the exhaust end and a return connecting said outer and inner tubes at the burner end of said element (steam superheater which can be adapted to existing boilers, pg 1, ln 11-12; Each of said outlets discharge the saturated steam into the saturated steam main 6, which is preferably constructed as seen in Figure 7 from which lead the circulating tubes 7, which are concentric with or positioned within the outer superheating tubes 8, each circulating tube having its end 9 terminating a short distance from the closed end 10 of its superheating tube 8, whereby a chamber is formed, so that the relatively cool saturated steam is conveyed to the hottest part of the superheater tube, thereby reducing the temperature at this point. The inner or circulating tube 7 is always maintained concentric with respect to the outer or superheating tube 8, Fig 1, 3, 7-9; pg 2, ln 56-71; it will be seen that from the time the steam leaves the circulating tube 7 and enters the superheating tube 8, it absorbs a considerable quantity of heat while passing between these two tubes, said tubes 8 being centrally located in the fire tubes 12 of the boiler and preferably running to within about six inches of the combustion chamber end of said fire tubes, Fig 2, 5; pg 3, ln 102-110; The three right-hand header sections as 21 are connected to the outlet manifold 22, seen at the right of Figure 1, which has the main outlet 23, Fig 1, pg 2, ln 103-107; a return connecting said outer and inner tubes at the burner end of said element - the boiler of MILNE has a combustion or burner end shown in Fig 2 and 3 at end 10 that is opposite an exhaust end at main outlet 23 as shown in Fig 1 where tubes 7 and 8 extend within the boiler from the burner or combustion end within about 6 Inches of return 10 to the exhaust end nearest to main outlet 23 with return 10 connecting said outer and inner tubes at the burner or combustion end of said element. In view of MILNE, it would have been obvious to one of ordinary skill in the art to have modified the superheater element of BOLTON to have had a burner end opposite an exhaust end; said tubes extending within said boiler from the burner end to the exhaust end; the return connecting said outer and inner tubes at the burner end of said element, so as to have increased the efficiency of the superheater of BOLTON by placing the ends of the tubes of BOLTON which were fluidly connected by the return to be as near to the burner of the boiler as possible.

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WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of:
Box No. V.2. Citations and explanations:

As per claim 8, BOLTON in view of STENNING and MILNE render obvious the superheater element of claim 7 and BOLTON further shows in Fig 1 wherein said return has a concave inner surface that is rotationally symmetric at all angles of rotation and wherein the center of said inner surface extends towards said inner tube (considering center to be the area forming the central portion, as for example the center of a room, the center of the inner surface of the return of BOLTON is considered to extend towards the inner tube c as it extends radially inwardly from the outer perimeter of the return towards the inner tube).

As per claim 9, BOLTON in view of STENNING and MILNE render obvious the superheater element of claim 8 and BOLTON further shows in Fig 1 wherein said concave inner surface as interpreted above demonstrates a shape of a sphere, which is a shape selected from the group consisting of a sphere, a parabola, and a hyperbola.

As per claim 10, BOLTON in view of MILNE render obvious the superheater element of claim 7, and BOLTON discloses wherein saturated steam introduced into said inlet manifold is directed into said inner tube by said return, and traveling within said inner tube towards the exhaust end of said element before exiting the outlet manifold (the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1, 2; pg 2, ln 26-30 - Fig 1 shows in the arrows in that figure wherein the saturated coming from the boiler into tube c is redirected at the far end of that tube by the return at the end of tube c into inner tube h to flow toward the exhaust end of the element before exiting the outlet manifold formed by the wall of header d with the openings for the exhaust end of tube h into compartment f). BOLTON does not specifically disclose wherein saturated steam introduced into said inlet manifold gains heat energy while traveling towards the burner end of said element, and then loses heat energy to the saturated steam while traveling towards the exhaust end of said element before exiting the outlet manifold. MILNE discloses wherein saturated steam introduced into said inlet manifold gains heat energy while traveling towards the burner end of said element, and then loses heat energy to the saturated steam while traveling towards the exhaust end of said element before exiting the outlet manifold (The operation is as follows: Saturated steam generated by the boiler passes through the connection 2, valve 3 and main steam pipe 4 into inlet manifold 5, and then enters the saturated steam header 6 and flows through circulating tubes 7 into the superheating tubes 8, Fig 1, 3; pg 3, ln 85-91; From the foregoing, it will be seen that from the time the steam leaves the circulating tube 7 and enters the superheating tube 8, it absorbs a considerable quantity of heat while passing between these two tubes, said tubes 8 being centrally located in the fire tubes 12 of the boiler and preferably running to within about six inches of the combustion chamber end of said fire tubes, the gases of combustion travelling between the outer periphery of tubes 8 and the inner periphery of tubes 12 on their way to the stack. These gases or products of combustion are obviously hottest at the point 10, where the relatively cool saturated steam first comes into contact with the superheating surfaces of superheater tube 8. The superheated steam passes down the chamber 48 between the header 18 and saturated steam main 6 into the outlet manifold 22, from whence it is conveyed to any desired point, Fig 1-3; pg 2, ln 102-123 - since the superheated steam is hottest at point 10, the return portion of superheater tube 8 at the combustion or burner end of the superheater element, that means that it cools off or loses heat energy to the saturated steam while traveling towards the exhaust end of said element before exiting the outlet manifold). In view of MILNE, it would have been obvious to one of ordinary skill in the art to have modified the arrangement of the concentric inner and outer tubes with respect to the burner end as taught by MILNE in the superheater element of BOLTON wherein saturated steam introduced into said inlet manifold gained heat energy while traveling towards the burner end of said element, and then lost heat energy to the saturated steam while traveling towards the exhaust end of said element before exiting the outlet manifold, so as to optimize the performance of the superheater element of BOLTON.

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WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Box No. V.2. Citations and explanations:

As per claim 11, BOLTON discloses a method for superheating steam using a superheater element inserted into the firetube of a firetube boiler (This invention relates to apparatus employed for superheating steam. Heretofore superheaters have been proposed in which Field tubes forming the superheater elements are placed within the fire tubes of the steam generator, pg 2, ln 5-7 - the steam generator is considered to be a boiler), comprises the steps of: providing a superheater element having an outer tube concentric about an inner tube (Within the ends of the tire tubes a, see Figures 1 and 2, and from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d. Each of the latter is divided into two compartments e, f by a partition g into which are expanded or otherwise secured open ended tubes h projecting within the tubes c before referred to, Fig 1, 2; pg 2, ln 20-25 - as can be seen in Fig 1, outer tube c is an outer tube concentric with inner tube h), a return connecting said outer and inner tubes at the closed end of said element (from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d, Fig 1, 2; pg 2, ln 20-22; the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1; pg 2, ln 26-30 - the semi-spherical closed end of tube c is clearly shown in Fig 1 to return saturated steam that has gone through tube c into tube h to be returned to header d, which return is considered to fluidly connect the outer and inner tubes at one end, which fluid connection is the same type of connection as the connection of the outer and inner tubes as disclosed in applicant.s disclosure, which is a fluid connection only as most clearly shown in Fig 4A of applicant.s disclosure), an inlet manifold connected to the exhaust end of said outer tube, and an outlet manifold connected to the exhaust end of said inner tube (In the arrangement illustrated at Figures 3 and 4, the header or distribution box d is divided into three compartments e, f and p. The saturated steam from the supply pipe i flows first to the compartment e, then by way of the tubes c and h to the compartment f, similarly to the compartment p and finally to the superheated steam supply pipe or outlet o by way of the branch pipe n, Fig 3, 4; pg 2, ln 37-41 - the plate at the side of compartment e which receives saturated steam from supply pipe i which then flows into the open end of outer tube c through openings in the plate that receive the open end of outer tube c is considered to be an inlet manifold connected to the exhaust end of said outer tube; the plate at the side of compartment e which receives saturated steam from the open end of inner tube h through openings in the plate that receive the open end of inner tube h which steam then flows into compartment f to flow to outlet o is considered to be an outlet manifold connected to the exhaust end of said inner tube); introducing saturated steam into said inlet manifold of said element (the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1, 2; pg 2, ln 26-30 - Fig 1 shows in the arrows where the saturated steam from the boiler is introduced into the inlet manifold of the element formed by the plate at the side of compartment e which receives saturated steam from supply pipe i which then flows into the open end of outer tube c through openings in the plate that receive the open end of outer tube c); causing said steam to travel within the outer tube towards the closed end of said element while absorbing heat energy from heated firetube gasses through the wall of the outer tube (from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d, Fig 1, 2; pg 2, ln 20-22; the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1, 2; pg 2, ln 26-30 - Fig 1 shows in the arrows in that figure wherein the saturated coming from the boiler into tube c is redirected at the far end of that tube by the return at the end of tube c into inner tube h to flow toward the exhaust end of the element before exiting the outlet manifold formed by the wall of header d with the openings for the exhaust end of tube h into compartment f); directing said now superheated steam into said inner tube by means of said return (from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d, Fig 1, 2; pg 2, ln 20-22; the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1, 2; pg 2, ln 26-30 - Fig 1 shows in the arrows in that figure wherein the saturated coming from the boiler into tube c is redirected at the far end of that tube by the closed end forming the return at the end of tube c into inner tube h); causing said superheated steam to travel within the inner tube towards the exhaust end of said element (the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1, 2; pg 2, ln 26-30 - Fig 1 shows in the arrows in that figure wherein the saturated coming from the boiler into tube c is redirected at the far end of that tube by the return at the end of tube c into inner tube h to flow toward the exhaust end of the element); and causing said superheated steam to exit said outlet manifold (the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1, 2; pg 2, ln 26-30 - Fig 1 shows in the arrows in that figure wherein the saturated coming from the boiler into tube c is redirected at the far end of that tube by the return at the end of tube c into inner tube h to flow toward the exhaust end of the element before exiting the outlet manifold formed by the wall of header d with the openings for the exhaust end of tube h into compartment f). BOLTON does not disclose the return at the end of tube c as being a separate element from the outer tube. STENNING discloses a superheater element of a steam superheater including co-axial tubular portions and an end cap attached to the tubular portions forming the return of on the end of the tubular portions (To these ends, the invention consists in a superheater element comprising co-axial tubular portions secured together at the ends to leave an annular duct, one end of which is provided with an inlet for the saturated steam and the other end with an outlet for the superheated steam, pg 1, para 5, ln 1-4; According to one specific form, the heater element is connected to the superheated steam pipe, k, referred to, by way of a return bend, m, of U form, lying beyond the operative length of the annulus, the ends of the U-legs, n, n, being united symmetrically with the annular heating space at diametrically opposite points, i, i, as shown, while the bend of the U at its centre is provided with a third leg, n.sup.1, which may be welded or otherwise secured to the superheated steam pipe, k, itself. Any other appropriate form of union may, however, be used. Into the annular space between the co-axial tubes, c and d, Fig 1-3; pg 4, para 2, ln 1-8; para 3, ln 1).

(Written Opinion of Claim 11 continued in next Supplemental Box)
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WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

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Supplemental Box

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Continuation of:
Box No. V.2. Citations and explanations:

(Continuation of Written Opinion of Claim 11)

In view of STENNING, it would have been obvious to one of ordinary skill in the art to have made the return of BOLTON in the form of a separate end cap from the end of outer tube c so as to have simplified the forming and construction of the tubing and end cap. BOLTON also does not disclose said boiler having a burner end opposite an exhaust end, nor that the outer tube concentric about the inner tube of the superheater extends within said boiler from the burner end to the exhaust end, nor that the return connects said outer and inner tubes at the burner end of said element, nor that steam is caused to travel within the outer tube towards the burner end of the element, nor that directing the superheated steam traveling in the inner tube towards the exhaust end of the element includes losing heat energy to said saturated steam in said outer tube through the wall of said inner tube; burner end of said element. MILNE discloses a superheater element within a fire tube (a novel manner of collocating each superheater element with respect to its inclosing standard fire tube, pg 1, ln 79-81) where the boiler has a burner end opposite an exhaust end with outer and inner tubes of the superheater extending within said boiler from the burner end to the exhaust end with tubes extending within said boiler from the burner end to the exhaust end and a return connecting said outer and inner tubes at the burner end of said element (steam superheater which can be adapted to existing boilers, pg 1, ln 11-12; Each of said outlets discharge the saturated steam into the saturated steam main 6, which is preferably constructed as seen in Figure 7 from which lead the circulating tubes 7, which are concentric with or positioned within the outer superheating tubes 8, each circulating tube having its end 9 terminating a short distance from the closed end 10 of its superheating tube 8, whereby a chamber is formed, so that the relatively cool saturated steam is conveyed to the hottest part of the superheater tube, thereby reducing the temperature at this point. The inner or circulating tube 7 is always maintained concentric with respect to the outer or superheating tube 8, Fig 1, 3, 7-9; pg 2, ln 56-71; it will be seen that from the time the steam leaves the circulating tube 7 and enters the superheating tube 8, it absorbs a considerable quantity of heat while passing between these two tubes, said tubes 8 being centrally located in the fire tubes 12 of the boiler and preferably running to within about six inches of the combustion chamber end of said fire tubes, Fig 2, 5; pg 3, ln 102-110; The three right-hand header sections as 21 are connected to the outlet manifold 22, seen at the right of Figure 1, which has the main outlet 23, Fig 1, pg 2, ln 103-107; a return connecting said outer and inner tubes at the burner end of said element - the boiler of MILNE has a combustion or burner end shown in Fig 2 and 3 at end 10 that is opposite an exhaust end at main outlet 23 as shown in Fig 1 where tubes 7 and 8 extend within the boiler from the burner or combustion end within about 6 inches of return 10 to the exhaust end nearest to main outlet 23 with return 10 connecting said outer and inner tubes at the burner or combustion end of said element. In view of MILNE, it would have been obvious to one of ordinary skill in the art to have modified the method for superheating steam of BOLTON to have had a burner end opposite an exhaust end; said tubes extending within said boiler from the burner end to the exhaust end; a return connecting said outer and inner tubes at the burner end of said element, wherein saturated steam introduced into said inlet manifold gained heat energy while traveling towards the burner end of said element, and then lost heat energy to the saturated steam while traveling towards the exhaust end of said element before exiting the outlet manifold, so as to have optimized the performance of the superheater element using the method for superheating steam of BOLTON as modified by MILNE.

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Supplemental Box

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Continuation of:
Box No. V.2. Citations and explanations:

As per claim 12, BOLTON discloses a method for fitting firetube boilers to superheat steam (This invention relates to apparatus employed for superheating steam. Heretofore superheaters have been proposed in which Field tubes forming the superheater elements are placed within the fire tubes of the steam generator, pg 2, ln 5-7 - the steam generator is considered to be a boiler) comprising the steps of: (a) providing a superheater element comprising an outer tube concentric about an inner tube (This invention relates to apparatus employed for superheating steam. Heretofore superheaters have been proposed in which Field tubes forming the superheater elements are placed within the fire tubes of the steam generator, pg 2, ln 5-7 - the steam generator is considered to be a boiler with a superheater element placed inside the fire tube; Within the ends of the fire tubes a, see Figures 1 and 2, and from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d. Each of the latter is divided into two compartments e, f by a partition g into which are expanded or otherwise secured open ended tubes h projecting within the tubes c before referred to, Fig 1,2; pg 2, ln 20-25 - as can be seen in Fig 1, outer tube c is an outer tube concentric with inner tube h; these tubes are considered to be the superheater element placed into the firetube); a return connecting said outer and inner tubes at one end (from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d, Fig 1, 2; pg 2, ln 20-22; the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1; pg 2, ln 26-30 - the semi-spherical closed end of tube c is clearly shown in Fig 1 to return saturated steam that has gone through tube c into tube h to be returned to header d, which return is considered to fluidly connect the outer and inner tubes at one end, which fluid connection is the same as the connection of the outer and inner tubes as disclosed in applicant.s disclosure, which is a fluid connection only as most clearly shown in Fig 4A of applicant.s disclosure; thus the closed end of tube c is considered to be a return connecting said outer and inner tubes at one end); an inlet manifold connected to the non-return end of said outer tube (In the arrangement illustrated at Figures 3 and 4, the header or distribution box d is divided into three compartments e, f and p. The saturated steam from the supply pipe i flows first to the compartment e, then by way of the tubes c and h to the compartment f, similarly to the compartment p and finally to the superheated steam supply pipe or outlet o by way of the branch pipe n, Fig 3, 4; pg 2, ln 37-41 - the plate at the side of compartment e which receives saturated steam from supply pipe i which then flows into the non-return end of outer tube c through openings in the plate that receive the non-return end of outer tube c is considered to be an inlet manifold connected to the non-return end of said outer tube); and an outlet manifold connected to the non-return end of said inner tube (In the arrangement illustrated at Figures 3 and 4, the header or distribution box d is divided into three compartments e, f and p. The saturated steam from the supply pipe i flows first to the compartment e, then by way of the tubes c and h to the compartment f, similarly to the compartment p and finally to the superheated steam supply pipe or outlet o by way of the branch pipe n, Fig 3, 4; pg 2, ln 37-41 - the plate at the side of compartment e which receives saturated steam from the non-return end of inner tube h through openings in the plate that receive the non-return end of inner tube h which steam then flows into compartment f to flow to outlet o is considered to be an outlet manifold connected to the non-return end of said inner tube). BOLTON does not disclose the return at the end of tube c as being a separate element from the outer tube; nor (b) providing an existing firetube boiler; and (c) inserting said superheater element into one or more firetubes of the existing firetube boiler. As per the return at the end of tube c being a separate element from the outer tube, STENNING discloses a superheater element of a steam superheater including co-axial tubular portions and an end cap attached to the tubular portions forming the return of on the end of the tubular portions (To these ends, the invention consists in a superheater element comprising co-axial tubular portions secured together at the ends to leave an annular duct, one end of which is provided with an inlet for the saturated steam and the other end with an outlet for the superheated steam, pg 1, para 5, ln 1-4; According to one specific form, the heater element is connected to the superheated steam pipe, k, referred to, by way of a return bend, m, of U form, lying beyond the operative length of the annulus, the ends of the U-legs, n, n, being united symmetrically with the annular heating space at diametrically opposite points, i, i, as shown, while the bend of the U at its centre is provided with a third leg, n.sup.1, which may be welded or otherwise secured to the superheated steam pipe, k, itself. Any other appropriate form of union may, however, be used. Into the annular space between the co-axial tubes, c and d, Fig 1-3; pg 4, para 2, ln 1-8; para 3, ln 1). In view of STENNING, it would have been obvious to one of ordinary skill in the art to have made the return of BOLTON in the form of a separate end cap from the end of outer tube c so as to have simplified the forming and construction of the tubing and end cap. As per (b) providing an existing firetube boiler; and (c) inserting said superheater element into one or more firetubes of the existing firetube boiler, MILNE discloses providing an existing firetube boiler (Our invention consists of a novel construction of steam superheater which can be adapted to existing boilers of every type without necessitating any change or dismantling of the latter, or employment of special fire tubes, provision being made for readily and expeditiously assembling the superheating devices with respect to any desired group of fire tubes in an existing boiler, pg 1, ln 10-19; Our entire apparatus is adaptable to boilers already in commission without any material change in their construction, pg 4, ln 57-59); and inserting said superheater element into one or more firetubes of the existing firetube boiler (provision being made for readily and expeditiously assembling the superheating devices with respect to any desired group of fire tubes in an existing boiler, pg 1, ln 15-19; Our header can be expeditiously and conveniently installed, since after the manifolds 5 and 22 are bolted in position, a superheating tube 8 made up in flange 17 is entered into each fire tube 12, which we may desire to utilize. The circulating tube 7 is then entered into the superheating tube 8, Fig 1-3; pg 4, ln 92-98). In view of MILNE, it would have been obvious to one of ordinary skill in the art to have retrofitted firetube boilers to superheat steam by modifying the method of BOLTON of providing the superheater elements of BOLTON, so as to further have utilized the steps of (b) providing an existing firetube boiler; and (c) inserting said superheater element into one or more firetubes of the existing firetube boiler, so as to have provided a method of increasing the heating capability existing boilers.

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In case **the space in any of the preceding boxes is not sufficient.**

Continuation of:
Box No. V.2. Citations and explanations:

As per claim 13, BOLTON in view of STENNING and MILNE render obvious the method of claim 12 and MILNE further discloses wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently (Our invention consists of a novel construction of steam superheater which can be adapted to existing boilers of every type without necessitating any change or dismantling of the latter, or employment of special fire tubes, provision being made for readily and expeditiously assembling the superheating devices with respect to any desired group of fire tubes in an existing boiler. To this end, our invention consists of a novel construction of inlet and outlet manifold, adapted to be connected to a series of sectional headers and their adjuncts, which can be cheaply constructed, readily installed in position, with respect to any standard fire tube boiler, and which are conveniently accessible at all times for the purposes of inspection, replacement and repairs, pg 1, ln 10-29 - when a firetube boiler has its superheater element replaced, as taught by MILNE, it is considered that replacing a superheating device that needs to be replaced, for example when that device is worn out, such replacement of a worn out superheater element is considered to be when a firetube boiler is retrofitted with a new superheater element to superheat steam more efficiently than was happening with the old worn out superheating device). In view of MILNE, it would have been obvious to one of ordinary skill in the art to have modified the method of BOLTON of providing the superheater elements of BOLTON wherein said firetube boiler already produced superheated steam and was retrofitted to superheat steam more efficiently, such that after a worn out superheater element was removed, a new superheater would have been inserted into a firetube of an existing firetube boiler that already produced superheated steam, so as to have replaced worn out superheater elements with new superheater elements to have improved the efficiency of the firetube boiler back up to where it had been when the original superheater elements were first inserted.

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Box No. V.2. Citations and explanations:

Claims 14, 15, 18 and 19 lack an inventive step under PCT Article 33(3) as being obvious over BOLTON in view of STENNING, MILNE and US 4,538,551 A to BRADY et al. (hereinafter 'BRADY').

As per claim 14, BOLTON discloses a firetube boiler for producing superheated steam (This invention relates to apparatus employed for superheating steam. Heretofore superheaters have been proposed in which Field tubes forming the superheater elements are placed within the fire tubes of the steam generator, pg 2, ln 5-7 - the steam generator is considered to be a firetube boiler for producing superheated steam) comprising (f) one or more superheater elements comprising an outer tube concentric about an inner tube (Within the ends of the fire tubes a, see Figures 1 and 2, and from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d. Each of the latter is divided into two compartments e, f by a partition g into which are expanded or otherwise secured open ended tubes h projecting within the tubes c before referred to, Fig 1,2; pg 2, ln 20-25 - as can be seen in Fig 1, outer tube c is an outer tube concentric with inner tube h); a return connecting said outer and inner tubes at one end (from the smoke box side of the boiler end plate b, are placed a series of tubes c, closed at one end as shown, and secured at their other or open ends into headers d, Fig 1, 2; pg 2, ln 20-22; the saturated steam coming from the boiler through the main supply pipe i and the branch pipes j enters one compartment e of one set or series of headers d and travels through the annular space between the tubes c and h, where it is superheated by the hot gases in the fire tube a, and then through the tubes h to the compartment f of the header d, Fig 1; pg 2, ln 26-30 - the semi-spherical closed end of tube c is clearly shown in Fig 1 to return saturated steam that has gone through tube c into tube h to be returned to header d, which return is considered to fluidly connect the outer and inner tubes at one end, which fluid connection is the same as the connection of the outer and inner tubes as disclosed in applicantLs disclosure, which is a fluid connection only as most clearly shown in Fig 4A of applicantLs disclosure; thus the closed end of tube c is considered to be a return connecting said outer and inner tubes at one end); an inlet manifold connected to the non-return end of said outer tube (In the arrangement illustrated at Figures 3 and 4, the header or distribution box d is divided into three compartments e, f and p. The saturated steam from the supply pipe i flows first to the compartment e, then by way of the tubes c and h to the compartment f, similarly to the compartment p and finally to the superheated steam supply pipe or outlet o by way of the branch pipe n, Fig 3, 4; pg 2, ln 37-41 - the plate at the side of compartment e which receives saturated steam from supply pipe i which then flows into the non-return end of outer tube c through openings in the plate that receive the non-return end of outer tube c is considered to be an inlet manifold connected to the non-return end of said outer tube); and an outlet manifold connected to the non-return end of said inner tube (In the arrangement illustrated at Figures 3 and 4, the header or distribution box d is divided into three compartments e, f and p. The saturated steam from the supply pipe i flows first to the compartment e, then by way of the tubes c and h to the compartment f, similarly to the compartment p and finally to the superheated steam supply pipe or outlet o by way of the branch pipe n, Fig 3, 4; pg 2, ln 37-41 - the plate at the side of compartment e which receives saturated steam from the non-return end of inner tube h through openings in the plate that receive the non-return end of inner tube h which steam then flows into compartment f to flow to outlet o is considered to be an outlet manifold connected to the non-return end of said inner tube); (f) wherein the superheater elements are inserted into at least one firetube and positioned within said firetube such that the inlet and outlet manifolds are oriented away from the return (Fig 1 of BOLTON shows the superheater elements outer and inner tubes c and h inserted into firetube a and positioned within said firetube such that the inlet and outlet manifolds formed by the plates defining compartment e are oriented away from the return formed on the end of outer tube c). BOLTON does not disclose the return at the end of tube c as being a separate element from the outer tube. BOLTON further does not disclose (a) a cylindrical boiler shell; (b) a burner; (c) the one or more firetubes carrying hot gases heated by said burner; (d) tube sheets; (e) one or more choke thimbles that control the flow of hot gases into the fire tubes; (f) wherein the superheater elements that are inserted into at least one firetube are positioned within said firetube such that the inlet and outlet manifolds are oriented away from the burner; and (g) wherein the hot gases from the burner superheat the saturated steam within the superheater element. As for the return, STENNING discloses a superheater element of a steam superheater including co-axial tubular portions and an end cap attached to the tubular portions forming the return of on the end of the tubular portions (To these ends, the invention consists in a superheater element comprising co-axial tubular portions secured together at the ends to leave an annular duct, one end of which is provided with an inlet for the saturated steam and the other end with an outlet for the superheated steam, pg 1, para 5, ln 1-4; According to one specific form, the heater element is connected to the superheated steam pipe, k, referred to, by way of a return bend, m, of U form, lying beyond the operative length of the annulus, the ends of the U-legs, n, n, being united symmetrically with the annular heating space at diametrically opposite points, i, i, as shown, while the bend of the U at its centre is provided with a third leg, n.sup.1, which may be welded or otherwise secured to the superheated steam pipe, k, itself. Any other appropriate form of union may, however, be used. Into the annular space between the co-axial tubes, c and d, Fig 1-3; pg 4, para 2, ln 1-8; para 3, ln 1). In view of STENNING, it would have been obvious to one of ordinary skill in the art to have made the return of BOLTON in the form of a separate end cap from the outer tube c so as to have simplified the forming and construction of the tubing and end cap. As for said boiler having (a) a cylindrical boiler shell; (b) a burner; (c) one or more firetubes carrying hot gases heated by said burner; (d) tube sheets; (f) wherein the superheater elements are inserted into at least one firetube and positioned within said firetube such that the inlet and outlet manifolds are oriented away from the burner; and (g) wherein the hot gases from the burner superheat the saturated steam within the superheater element, MILNE shows the boiler thereof having a cylindrical boiler shell in Fig 1. MILNE further discloses a burner (the combustion chamber end of said fire tubes, pg 3, ln 109-110 - the combustion chamber is considered to refer to a burner). MILNE also discloses one or more firetubes carrying hot gases heated by said burner (it will be seen that from the time the steam leaves the circulating tube 7 and enters the superheating tube 8, it absorbs a considerable quantity of heat while passing between these two tubes, said tubes 8 being centrally located in the fire tubes 12 of the boiler and preferably running to within about six inches of the combustion chamber end of said fire tubes, Fig 2, 5; pg 3, ln 102-110). MILNE also discloses tube sheets (said fire tubes being secured in their tube sheets 14 and 15, Fig 2; pg 2, ln 76-77).

(Written opinion of claim 14 continued in next Supplemental Box)

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Continuation of:
Box No. V.2. Citations and explanations:

(Continuation of Written Opinion of Claim 14)

MILNE further discloses wherein the superheater elements are inserted into at least one firetube and positioned within said firetube such that the inlet and outlet manifolds are oriented away from the burner, and wherein the hot gases from the burner superheat the saturated steam within the superheater element (The operation is as follows: Saturated steam generated by the boiler passes through the connection 2, valve 3 and main steam pipe 4 into inlet manifold 5, and then enters the saturated steam header 6 and flows through circulating tubes 7 into the superheating tubes 8, Fig 1, 3; pg 3, ln 85-91; From the foregoing, it will be seen that from the time the steam leaves the circulating tube 7 and enters the superheating tube 8, it absorbs a considerable quantity of heat while passing between these two tubes, said tubes 8 being centrally located in the fire tubes 12 of the boiler and preferably running to within about six inches of the combustion chamber end of said fire tubes, the gases of combustion travelling between the outer periphery of tubes 8 and the inner periphery of tubes 12 on their way to the stack. These gases or products of combustion are obviously hottest at the point 10, where the relatively cool saturated steam first comes into contact with the superheating surfaces of superheater tube 8. The superheated steam passes down the chamber 48 between the header 18 and saturated steam main 6 into the outlet manifold 22, from whence it is conveyed to any desired point, Fig 1-3; pg 2, ln 102-123). In view of MILNE, it would have been obvious to one of ordinary skill in the art to modify the firetube boiler to include (a) a cylindrical boiler shell; (b) a burner; (c) one or more firetubes carrying hot gases heated by said burner; (d) tube sheets; (f) wherein the superheater elements are inserted into at least one firetube and positioned within said firetube such that the inlet and outlet manifolds are oriented away from the burner; and (g) wherein the hot gases from the burner superheat the saturated steam within the superheater element, so as to provided an improved structural support for the boiler in the form of the cylindrical boiler shell and the tube sheets and so as to have provided improved means to heat the superheater element in the form of the burner, the firetubes carrying hot gases being heated by the burner, wherein the superheater elements were inserted into the at least one firetube and positioned within said firetube such that the inlet and outlet manifolds were oriented away from the burner, and wherein the hot gases from the burner superheated the saturated steam within the superheater element. As for one or more choke thimbles that control the flow of hot gases into the fire tubes, BRADY discloses a choke in the combustion chamber of a boiler that provide for more complete burning in the combustion chamber and more efficiency in the boiler (The present invention relates to a new and improved refractory choke for a high intensity combustor; and more particularly, to a new and improved choke of refractory material including elements for improving the thermal conductivity of the refractory material and to a new and improved method for improving the combustion of a boiler, col 1, ln 8-14; Choke 21 is a restriction in the path of flow of combustion gases strategically placed in the system to promote recirculation zones 24. The recirculation zones 24 are formed by vortexes that mix unburned particles to obtain more complete burning. Without recirculation zones 24, there is carbon buildup on the choke 21 causing a back up in the flow and reduced efficiency of boiler 10, Fig 1, 2; col 2, ln 66 to col 3, ln 5). In view of BRADY, it would have been obvious to one of ordinary skill in the art to have modified the firetube boiler of BOLTON to have included one or more choke thimbles that controlled the flow of hot gases into the fire tubes, which choke was a choke in the combustion area of the boiler, so as to have increased the efficiency of the boiler and that by increasing the efficiency of the boiler, raised the temperature of the steam supplied to the fire tubes, and thus controlled the flow of hot gases into the fire tubes, by increasing the temperature of those gases.

As per claim 15, BOLTON in view of STENNING, MILNE and BRADY render obvious the firetube boiler for producing superheated steam of claim 14 and BOLTON further discloses wherein superheater elements are used in more than one firetube (see superheater elements c and h in fire tubes a in Fig 1 of BOLTON).

As per claim 18, BOLTON in view of STENNING, MILNE and BRADY render obvious the firetube boiler of claim 14, and BRADY further discloses wherein said choke thimbles are fabricated from heat resistant materials (The present invention relates to a new and improved refractory choke for a high intensity combustor; and more particularly, to a new and improved choke of refractory material including elements for improving the thermal conductivity of the refractory material and to a new and improved method for improving the combustion of a boiler, col 1, ln 8-14 - a refractory material is a material resistant to heat). In view of BRADY, it would have been obvious to one of ordinary skill in the art to have modified the firetube boiler of BOLTON to have made the choke taught by BRADY to have been fabricated from heat resistant materials, so that it would have been better able to withstand the high temperatures in the boiler of BOLTON.

As per claim 19, BOLTON in view of STENNING, MILNE and BRADY render obvious the firetube boiler of claim 18. As per making said heat resistant material to be ceramic, BRADY discloses wherein wherein said choke is fabricated from heat resistant materials (The present invention relates to a new and improved refractory choke for a high intensity combustor; and more particularly, to a new and improved choke of refractory material including elements for improving the thermal conductivity of the refractory material and to a new and improved method for improving the combustion of a boiler, col 1, ln 8-14 - a refractory material is a material resistant to heat). A well-known refractory material is ceramic, as, for example, in ceramic heaters. To one of ordinary skill in the art in following the teachings of BRADY of providing a choke thimble for the boiler of BOLTON made out of heat resistant material, it would have been obvious to that person of ordinary skill in the art to choose ceramic for the heat resistant material, because it would have provided improved heat resistant properties for the choke when provided for the modified boiler of BOLTON as taught by BRADY.

-- Please see next Supplemental Box --

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.

PCT/US 17/65485

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of:
Box No. V.2. Citations and explanations:

Claims 16 and 17 meet the criteria set forth under PCT Article 33(2)-(3) because while various references teach elements of the claims, none of the prior art teaches or fairly suggests the particular combination of elements recited in dependent claims 17 and 18.

The prior art is represented by:

GB 24,407 A (BOLTON)
GB 18,144 A to STENNING et al. (hereinafter 'STENNING')
US 1,495,759 A to MILNE et al. (hereinafter 'MILNE')
US 4,538,551 A to BRADY et al. (hereinafter 'BRADY')
GB 10,007 A to HEENAN & FROUDE LIMITED (hereinafter 'HEENAN')

As per claim 16, BOLTON in view of STENNING, MILNE and BRADY render obvious the firetube boiler of claim 14, but none of BOLTON, STENNING, MILNE nor BRADY further disclose wherein only some of the firetubes have superheater elements and choke thimbles are used on all the firetubes. BRADY discloses using a choke in the combustion chamber of a boiler (The present invention relates to a new and improved refractory choke for a high intensity combustor; and more particularly, to a new and improved choke of refractory material including elements for improving the thermal conductivity of the refractory material and to a new and improved method for improving the combustion of a boiler, col 1, ln 8-14), but does not disclose using choke thimbles on all of the firetubes of a boiler.

As per claim 16, HEENAN discloses wherein only some of the firetubes have superheater elements (This invention relates to improvements in superheaters, pg 2, ln 3; superheater tube A is inserted in some or all of the fire tubes B, Fig 1; pg 2, ln 2).

As per claim 16, there is no suggestion from BOLTON, STENNING, MILNE, BRADY nor HEENAN that would have rendered obvious to one of ordinary skill in the art providing a plurality of choke thimbles, nor using the choke thimbles on the fire tubes, wherein choke thimbles were used on all of the firetubes particularly in the firetube boiler of claim 14 which further included wherein only some of the firetubes had superheater elements and choke thimbles were used on all the firetubes.

As per claim 17, BOLTON in view of STENNING, MILNE and BRADY render obvious the firetube boiler of claim 14, but none of BOLTON, STENNING, MILNE nor BRADY further disclose wherein only some of the firetubes have superheater elements and choke thimbles are used on only the firetubes that do not have superheater elements. BRADY discloses using a choke in the combustion chamber of a boiler (The present invention relates to a new and improved refractory choke for a high intensity combustor; and more particularly, to a new and improved choke of refractory material including elements for improving the thermal conductivity of the refractory material and to a new and improved method for improving the combustion of a boiler, col 1, ln 8-14), but does not disclose using choke thimbles on only the firetubes that do not have superheater elements.

As per claim 17, HEENAN discloses wherein only some of the firetubes have superheater elements (This invention relates to improvements in superheaters, pg 2, ln 3; superheater tube A is inserted in some or all of the fire tubes B, Fig 1; pg 2, ln 2).

As per claim 17, there is no suggestion from BOLTON, STENNING, MILNE, BRADY nor HEENAN that swould have rendered obvious to one of ordinary skill in the art providing a plurality of choke thimbles, nor using the choke thimbles on the fire tubes, wherein choke thimbles were used on some of the firetubes particularly in the firetube boiler of claim 14 which further included wherein only some of the firetubes had superheater elements and choke thimbles were used on only the firetubes that do not have superheater elements.

Thus, claims 16 and 17 meet the criteria set out in PCT Article 33(2)-(3).

Claims 1-19 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used by industry.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 17/65485

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F22G 7/02 (2018.01)
CPC - F22G 7/02; F22G 1/005; F22G 3/005; F22G 3/006; F22B 9/00; F22B 13/00; F22B 31/00; F22B 31/08; F22B 37/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y --- A	GB 24,407 A (BOLTON) 21 June 1911 (21.06.1911), entire document, especially Fig 1-4; pg 2, ln 5-7, ln 20-30, ln 37-41	1-15, 18, 19 --- 16, 17
Y --- A	GB 18,144 A (STENNING et al.) 21 January 1915 (21.01.1915), Fig 1-3; pg 1, para 5, ln 1-4; pg 4, para 2, ln 1-8, para 3, ln 1	1-15, 18, 19 --- 16, 17
Y	US 2009/0266529 A1 (JAHIER) 29 October 2009 (29.10.2009), para [0001]; para [0003]; para [0033]	3, 4
Y	US 5,207,776 A (PEARCE) 04 May 1993 (04.05.1993), col 1, ln 24-25, ln 57-67; col 2, ln 6-10	5
Y --- A	US 1,495,759 A (MILNE et al.) 27 May 1924 (27.05.1924), Fig 1-3, 5, 7-9; pg 1, ln 01-19, ln 79-81; pg 2, ln 56-71, ln 76-77, ln 102-123; pg 3, ln 85-91, ln 102-110; pg 4, ln 57-59, ln 92-98	7-15, 18, 19 --- 16, 17
Y --- A	US 4,538,551 A (BRADY et al.) 03 September 1985 (03.09.1985), col 1, ln 8-14	14, 15, 18, 19 --- 16, 17
A	GB 10,007 A (HEENAN & FROUDE LIMITED) 27 May 1913 (27.05.1913), Fig 1; pg 2, ln 2	16, 17
A	US 4,023,508 A (CANTRELL, JR. et al.) 17 May 1977 (17.05.1977), col 1, ln 61-63; col 3, ln 36-41	19

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 May 2018	20 JUN 2018
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 17/65485

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,056,209 A (OHASHI et al.) 15 October 1991 (15.10.1991), Fig 14; col 6, ln 29-36; col 18, ln 48 to col 19, ln 8	5
A	US 1,725,485 A (SHUPERT) 20 August 1929 (20.08.1929), entire document	1-19
A	US 2,007,559 A (BERGER) 09 July 1935 (09.07.1935), entire document	1-19
A	US 3,259,108 A (CRAIG et al.) 05 July 1966 (05.07.1966), entire document	1-19

CLAIMS

I claim:

1. A superheater element for conducting superheated steam within a firetube of a firetube boiler comprising:

an outer tube concentric about an inner tube;

a return connecting said outer and inner tubes at one end;

an inlet manifold connected to the non-return end of said outer tube; and

an outlet manifold connected to the non-return end of said inner tube.

2. The superheater element of claim 1 wherein said return has a concave inner surface that is rotationally symmetric at all angles of rotation and wherein the center of said inner surface extends towards said inner tube.

3. The superheater element of claim 1 wherein said inner and outer tubes are fabricated from material with high thermal conductivity characteristics.

4. The superheater element of claim 1 wherein said inner tube is fabricated from material selected from a group comprising of carbon steel, stainless steel, and steel comprising chromium, molybdenum, and manganese alloys.

5. The superheater element of claim 1 wherein said return is fabricated from a high carbon alloy steel encased within boiler code compliant materials.

6. The superheater element of claim 1 wherein the wall of the inner tube is shaped and sized to maximize the thermal conductivity between the inner and outer tube, giving consideration to the tube material, and the pressure and temperature of the superheated steam flowing through said inner and outer tubes.

7. A superheater element for superheating saturated steam within a firetube of a firetube boiler, said boiler having a burner end opposite an exhaust end, comprising:

an outer tube concentric about an inner tube, said tubes extending within said boiler from the burner end to the exhaust end;

a return connecting said outer and inner tubes at the burner end of said element;

an inlet manifold connected to the exhaust end of said outer tube; and

an outlet manifold connected to the exhaust end of said inner tube.

8. The superheater element of claim 7 wherein said return has a concave inner surface that is rotationally symmetric at all angles of rotation and wherein the center of said inner surface extends towards said inner tube.

9. The superheater element of claim 8 wherein said concave inner surface demonstrates a shape selected from the group consisting of a sphere, a parabola, and a hyperbola.

10. The superheater element of claim 7, wherein saturated steam introduced into said inlet manifold gains heat energy while traveling along the outer tube towards the burner end of said element, is directed into said inner tube by said return, and then loses heat energy to the saturated steam within said outer tube while traveling within said inner tube towards the exhaust end of said element before exiting the outlet manifold.

11. A method for superheating steam using a superheater element inserted into the firetube of a firetube boiler, said boiler having a burner end opposite an exhaust end, comprises the steps of:

providing a superheater element having an outer tube concentric about an inner tube that extends within said boiler from the burner end to the exhaust end, a return connecting said outer and inner tubes at the burner end of said element, an inlet manifold connected to the exhaust end of said outer tube, and an outlet manifold connected to the exhaust end of said inner tube;

introducing saturated steam into said inlet manifold of said element;

causing said steam to travel within the outer tube towards the burner end of said element while absorbing heat energy from heated firetube gasses through the wall of the outer tube;

directing said now superheated steam into said inner tube by means of said return;

causing said superheated steam to travel within the inner tube towards the exhaust end of said element while losing heat energy to said saturated steam in said outer tube through the wall of said inner tube; and

causing said superheated steam to exit said outlet manifold.

12. A method for retrofitting firetube boilers to superheat steam comprising the steps of:

(a) providing a superheater element comprising an outer tube concentric about an inner tube; a return connecting said outer and inner tubes at one end; an inlet manifold connected to the non-return end of said outer tube; and an outlet manifold connected to the non-return end of said inner tube;

(b) providing an existing firetube boilers; and

(c) inserting said superheater element into one or more firetubes of the existing firetube boiler.

13. The method of claim 12 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently.

14. A firetube boiler for producing superheated steam comprising

(a) a cylindrical boiler shell;

(b) a burner;

(c) one or more firetubes carrying hot gases heated by said burner;

(d) tube sheets;

(e) one or more choke thimbles that control the flow of hot gases into the firetubes;

(f) one or more superheater elements comprising an outer tube concentric about an inner tube; a return connecting said outer and inner tubes at one end; an inlet manifold connected to the non-return end of said outer tube; and an outlet manifold connected to the non-return end of said inner tube;

(f) wherein the superheater elements are inserted into at least one firetube and positioned within said firetube such that the inlet and outlet manifolds are oriented away from the burner; and

(g) wherein the hot gases from the burner superheat the saturated steam within the superheater element.

15. The firetube boiler for producing superheated steam of claim 14 wherein superheater elements are used in more than one firetube.

16. The firetube boiler of claim 14, wherein only some of the firetubes have superheater elements and choke thimbles are used on all the firetubes.

17. The firetube boiler of claim 14, wherein only some of the firetubes have superheater elements and choke thimbes are used on only the firetubes that do not have superheater elements.

18. The firetube boiler of claim 14, wherein said choke thimbles are fabricated from heat resistant materials.

19. The firetube boiler of claim 14, wherein said heat resistant material is ceramic.

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December 8, 2021

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BY FAX

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2021/12/08
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OPIC-CIPO L000001410

Commissioner of Patents,
Canadian Intellectual Property Office
Place du Portage I
50 Victoria Street
Ottawa- Gatineau, Canada
K1A 0C9

PPH

Dear Sirs:

Re: **Canadian Patent Application Ser. No. 3,048,401**
Title: **ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS**
Owner: **JAMES MATTHEW AUSTIN**
Entity: **Small**
Our file: **0141988-00001**

REQUESTING EXAMINATION & PPH

The Applicant hereby requests examination under subsection 35(1) of the *Patent Act*. Applicant has enclosed the examination fee. Applicant also requests accelerated examination of the application under the Patent Prosecution Highway (PPH).

No accelerated examination fee is required under the PPH program. Applicant has enclosed a voluntary amendment to amend the claims to sufficiently correspond to the claims issued in U.S. Patent No. 10,775,040.

FEES

The Commissioner is authorized to debit the fees outlined below to our CIPO Deposit Account No. 600000786 or credit card in accordance with the attached Fee Payment Form:

Fee:	Request examination
Amount:	$408.00

The Applicant provides the following Amendments and Remarks:

AMENDMENTS

To the Claims

Please find enclosed a set of amended claims. Please replace the claims on file with the enclosed set of amended claims.

REMARKS

Applicant asserts that the submitted claims sufficiently correspond to one or more of those claims indicated as allowable in the Office of Earlier Examination (OEE).

No new matter has been added.

The Applicant believes that the application, as amended, is now in condition for allowance. The Applicant respectfully solicits allowance of the amended application as enclosed herein.

General payment authorization:

Should the fees submitted with this letter be insufficient to cover all of the fees for which payment is explicitly or implicitly requested by this letter and indication of the intent of the owner to maintain this matter in good standing, CIPO is authorized to charge the amount of the insufficiency using the deposit account or credit card payment methods specified in the accompanying Fee Payment Form.

All of which is respectfully submitted.

Yours very truly,

MLT AIKINS LLP

Scott E. Davidson
/AML/jps

Encl.

Date reçue / Date received 2021-12-08

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

Innovation, Sciences et Développement économique Canada
Office de la propriété intellectuelle du Canada

Internal Code
PPH-047

REQUEST FORM FOR PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PROGRAM

This form is used to make a request for accelerated examination at the Canadian Intellectual Property Office (CIPO) under either the Global Patent Prosecution Highway (GPPH) agreement or one of CIPO's bilateral Patent Prosecution Highway (PPH) agreements.

Privacy Notice

All personal information created, held or collected by the Canadian Intellectual Property Office is protected under the *Privacy Act*. This means that you will be informed of the purpose for which it is being collected and how to exercise your right of access to that information. You will be asked for your consent where appropriate. Read the full notice: cipo.ic.gc.ca/notice.

To ensure efficient processing of your application, please clearly mark each part of your submission with the term "PPH".

A. Bibliographic Data

CIPO Application Number (if known) 3048401

B. Requests

Has a PPH request previously been submitted for this application? ◯ Yes ◉ No

Applicant requests participation in the Patent Prosecution Highway (PPH) pilot program based on:

Office of Earlier Examination (OEE)	United States Patent and Trademark Office
OEE Application Number (Includes PCT Application Number)	15/381,682
OEE Work Products Type	☑ National/Regional Office Action(s) ☐ International (WO-ISA, WO-IPEA or IPRP)
OEE Application Filing Date (YYYY-MM-DD)	2016-12-16
OEE Application Priority Date (YYYY-MM-DD)	2016-12-16

☑ The CIPO application and corresponding PPH Partner Office application(s), identified above, have the same earliest priority/filing date.

Applicant requests the Canadian patent application be opened to public inspection.

For PPH requests the Canadian patent application must be open to public inspection in accordance with subsection 10(2) of the Patent Act. If the Canadian patent application is not open to public inspection:

The applicants hereby request that this application be immediately opened to public inspection in accordance with subsection 10(2) of the Patent Act.

Name	Signature	Date

C. Required Documents

I. OEE Work Products and, if required, Translations

1.
◯ A copy of OEE work products is attached; or
◉ The office is requested to retrieve documents via the Dossier Access System or PATENTSCOPE

2.
◯ A translation of documents in 1 in a language accepted by the Office is attached; or
◯ The office is requested to retrieve documents via the Dossier Access System or PATENTSCOPE; or
◉ None of the above

II. Patentable/Allowable Claims Determined by OEE and, if required, Translations

3.
◯ A copy of all claims determined to be patentable/allowable by OEE is attached; or
◉ The office is requested to retrieve documents via the Dossier Access System or PATENTSCOPE

4.
◯ A translation of documents in 3 in a language accepted by the Office is attached; or
◯ The office is requested to retrieve documents via the Dossier Access System or PATENTSCOPE; or
◉ None of the above

Date reçue / Date received 2021-12-08

III. Documents Cited in OEE Work Products (optional)

5.

- ◯ References not supplied; or
- ◉ a copy of all documents cited in OEE work products is attached (excluding patent documents); or
- ◯ no references cited; or
- ◯ none of the above.

IV. Previously Submitted Documents

6.

- ☐ If any of the above mentioned documents have been submitted before, please specify:

V. Identification of Documents

Please indicate in the table below or on an attached sheet the relevant documents referred to in 1, 2, 3 and 4 to be retrieved via the Dossier Access System or PATENTSCOPE.

Document Name used in Dossier Access System or PATENTSCOPE	Date (YYYY-MM-DD)
Notice of Allowance and Fees Due (PTOL-85)	2020-08-06
Issue Notification	2020-08-26
Claims	2020-07-09
Applicant Argument/Remarks Made in Amendment	2020-07-09

D. Claims Correspondence

- ◉ All the claims in the application sufficiently correspond to the patentable/allowable claims in the OEE application; or
- ◯ Claims correspondence is explained in the following table

CIPO Application Claims	Corresponding OEE claims	Explanation regarding the correspondence

E. Box VIII Observations (for PPH requests based off international work products only)

- ◯ In case any observation is described in Box VIII of the WO-ISA, WO-IPEA, and/or IPRP that forms the basis of the PCT-PPH request, the applicant has attached an explanation of why the claims are not subject to the observation described in Box VIII; or
- ◯ There are no observations in Box VIII of the WO-ISA, WO-IPEA, and/or IPRP that forms the basis of the PCT-PPH request; or
- ◉ None of the above.

F. Other amendments to application (optional)

- ◯ The applicant has reviewed the application, and the specification on file conforms with Canadian patent application requirements and practice; or
- ◯ The applicant is amending the specification to conform with Canadian patent application requirements and practice; or
- ◉ None of the above.

Name(s) of applicant(s) or representative(s)	Scott E. Davidson
Date (YYYY-MM-DD)	2021-12-08

CLAIMS

1. A superheater element for superheating steam within a firetube of a firetube boiler comprising:

an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube;

and a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube.

2. A superheater element of claim 1 wherein said interior face of said return is described as the bottom-half of the surface of a horn torus wherein the axis of rotational symmetry of said horn torus is the central axis shared by said outer and inner tubes.

3. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving a parabola in a three-dimensional space about an axis of rotation that intersects with said parabola and is parallel with the axis of symmetry of said parabola wherein said axis of rotation is the central axis shared by said outer and inner tubes.

Date reçue / Date received 2021-12-08

4. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving one branch of a hyperbola in a three-dimensional space about an axis that intersects with said hyperbola branch and is parallel with the axis of symmetry of said hyperbola branch, wherein said axis of rotation is the central axis shared by said outer and inner tubes.

5. The superheater element of claim 1 wherein said boiler has a burner end opposite an exhaust end and said superheater element extending within said boiler from the burner end to the exhaust end.

6. The superheater element of claim 1 wherein the wall of the inner tube is shaped and sized to maximize the thermal conductivity between the inner and outer tubes, giving consideration to the tube material, and the pressure and temperature of the superheated steam flowing through said inner and outer tubes.

7. The superheater element of claim 1 wherein said inner and outer tubes are fabricated from material selected from a group consisting of carbon steel, stainless steel, and steel comprising chromium, molybdenum, and manganese alloys.

8. The superheater element of claim 1 wherein said return is fabricated from erosion resistant material comprising heat treated high carbon alloy steels.

9. The superheater element of claim 1 wherein said return is fabricated from erosion resistant material comprising turbine blade material.

10. The superheater element of claim 5, wherein saturated steam introduced into said inlet manifold gains heat energy while traveling along the outer tube towards the exhaust end of said boiler, is directed into said inner tube by said return, and then loses heat energy to the saturated steam within said outer tube while traveling within said inner tube towards the burner end of said boiler before exiting the outlet manifold.

Date reçue / Date received 2021-12-08

11. A method for superheating steam using a superheater element inserted into the firetube of a firetube boiler, said boiler having a burner end opposite an exhaust end, comprising the steps of:

providing a superheater element having an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube;

and a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a-point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube introducing saturated steam into said inlet manifold of said element;

causing said steam to travel within the outer tube towards the exhaust end of said boiler while absorbing heat energy from heated firetube gasses through the wall of the outer tube;

directing said now superheated steam into said inner tube by means of said return;
causing said superheated steam to travel within the inner tube towards the burner end of said boiler while losing heat energy to said saturated steam in said outer tube through the wall of saki inner tube; and

causing said superheated steam to exit said outlet manifold.

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12. A method for retrofitting firetube boilers to superheat steam comprising the steps of:

(a) providing one or more superheater elements each comprising an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube and a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube;

(b) providing an existing firetube boiler; and

(c) inserting said superheater elements into one or more firetubes of the existing firetube boiler.

13. The method of claim 12 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently compared with before the retrofit, by reducing the heat loss from the superheated steam to the boiler.

14. A method for retrofitting firetube boilers to superheat steam comprising the steps of:

Date reçue / Date received 2021-12-08

(a) providing one or more superheater elements each comprising an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube; and

a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube;

(b) providing an existing firetube boiler;

(c) providing one or more choke thimbles;

(d) inserting said superheater elements into one or more firetubes of the existing firetube boiler; and

(e) inserting a choke thimble into each firetube of the existing firetube boiler.

15. The method for retrofitting firetube boilers to superheat steam of claim 14, wherein only some of the firetubes have superheater elements and choke thimbles are used on only the firetubes that do not have superheater elements.

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16. The method of claim 14 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently compared with before the retrofit, by reducing the heat loss from the superheated steam to the boiler.

Date reçue / Date received 2021-12-08

6 January 2022 (06-01-2022)

MLT AIKINS LLP
1500 - 1874 SCARTH ST
REGINA Saskatchewan S4P 4E9

Application No.	:	**3,048,401**
PCT No.	:	**US2017065485**
Owner	:	AUSTIN, JAMES MATTHEW
Title	:	**ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS**
Classification	:	F22G 1/02 (2006.01)
Your File No.	:	**0141988-00001**
Examiner	:	Julien Daigle, P. Eng.

YOU ARE HEREBY NOTIFIED OF A REQUISITION BY THE EXAMINER IN ACCORDANCE WITH SUBSECTION 86(2) OF THE *PATENT RULES*. IN ORDER TO AVOID ABANDONMENT UNDER PARAGRAPH 73(1)(*a*) OF THE *PATENT ACT*, A WRITTEN REPLY MUST BE RECEIVED WITHIN **FOUR (4)** MONTHS AFTER THE ABOVE DATE.

This application has been accepted into the Patent Prosecution Highway (PPH), and will receive accelerated examination.

This application has been examined taking into account the:

Description,	pages 1-16, as originally filed;
Claims,	1-16, as received on 8 December 2021 (08-12-2021) during the national phase; and
Drawings,	pages 1-8, as originally filed.

This application has been examined taking into account applicant's correspondence on prior art received in this office on 8 December 2021 (08-12-2021).

The number of claims in this application is 16.

A search of the prior art has thus far failed to reveal any pertinent references.

The examiner has identified the following defects in the application:

Claim 11 is indefinite and does not comply with subsection 27(4) of the *Patent Act*. The following terms have no antecedents: “the wall of the outer tube” (claim 11) and “the wall of saki inner tube” (claim 11).

Pursuant to section 193 of the *Patent Rules*, the pages of the description and claims are not numbered consecutively and do not comply with subsection 73(1) of the former *Patent Rules*. The description ends on page 16 while the claims being on page 11. The claims should begin on page 17.

In view of the foregoing defects, the applicant is requisitioned, under subsection 86(2) of the *Patent Rules*, to amend the application in order to comply with the *Patent Act* and the *Patent Rules* or to provide arguments as to why the application does comply.

Under section 102 of the *Patent Rules*, any amendment made in response to this requisition must be accompanied by a statement explaining the purpose of the amendment and identifying the differences between the new page and the replaced page.

To continue accelerated examination under the PPH, the applicant is reminded that any amended claims must sufficiently correspond to one or more of those claims indicated as allowable in the Office of Earlier Examination (OEE). If any amendment in response to this requisition results in claims which do not sufficiently correspond, the application may be removed from the PPH.

In order to ensure that correspondence related to PPH applications is correctly processed, the applicant is asked to clearly mark each page of the covering letter with the term **"PPH"** in the upper right hand corner of the page.

Julien Daigle, P. Eng.
Patent Examiner
819-639-7786

As per CIPO Client Service Standards, a response to a telephone enquiry or voice mail should be provided by the end of the next business day. In the event that attempts to reach the examiner are unsuccessful, the examiner's Section Head, Maxime Bazinet, can be reached at 819-639-0370.

For general inquiries: 1-866-997-1936 or for more options see http://www.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/wr00006.html.

CIPO values your feedback and invites you to complete a short and anonymous ongoing survey on patent examination products and services. You can access the survey at the following link: https://www.surveymonkey.com/r/PPE_EPBdB.

Examination Search Report

Box I: General Information

Application No.	3,048,401	Search Report Date	2022-01-04
Title	ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS		
Examiner	Julien Daigle	Search Conducted?	Yes

Box II: Family Prosecution

Family Member	File Wrapper Reviewed	Status of Prosecution
WO2018111730	2022-01-04	Completed
US10775040B2	2022-01-04	Completed

Box III: Search History

Claims Searched	1-16	Date of Search	2022-01-04

Type of Search Conducted (select all that apply):

Canadian first to file search	■	Supplemental/top up search	□
Inventor/applicant search	□	Non laid open search	□
Comprehensive search	□	In-house searcher	□

Search History from Databases Consulted:

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##### CANADIAN PATENT DATABASE/INTELLECT ##########

filing-date:[2012-12-09 TO 2019-02-24] AND ipc:(F22G\ 1/02 OR F22G\ 3/00)
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February 23, 2022

BY FAX

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Commissioner of Patents,
Canadian Intellectual Property Office
Place du Portage I
50 Victoria Street
Ottawa- Gatineau, Canada
K1A 0C9

PPH

Dear Sirs:

Re: **Canadian Patent Application Ser. No. 3,048,401**
Title: **ANNULAR SUPERHEATING ELEMENT FOR FIRETUBE BOILERS**
Owner: **James Matthew Austin**
Our file: **0141988-00001**

Responsive to the Examiner's Report dated **January 6, 2022**, with respect to the above-captioned patent application, the Applicant provides the following Amendments and Remarks. This application was accepted into the Patent Prosecution Highway (PPH).

AMENDMENTS

To the Claims:

Please find enclosed new amended pages 17-22 including amended claim 11. Please remove previous claim pages 11-16 and replace them with the enclosed new amended pages 17-22 containing claims 1-16.

REMARKS

Indefiniteness

1) The Examiner objected to claim 11 as being indefinite and not complying with subsection 27(4) of the *Patent Act*, specifically alleging that the terms "the wall of the outer tube" and "the wall of saki inner tube" have no antecedents. In response to this objection, claim 11 has been amended to change the term "the wall of the outer tube" to "a wall of the outer tube", thereby introducing the term "a wall" and overcoming this objection.

Further in response to this objection, claim 11 has been amended to change the term "the wall of saki inner tube" to "a wall of the inner tube", thereby introducing the term "a wall" and correcting the misspelled term "saki" to "the", thereby overcoming this objection.

It is respectfully pointed out that the term "saki" was introduced from claim 11 of the commonly owned U.S. patent which was the basis for PPH entry. It is believed the term "saki" in the U.S. patent was meant to be "said". To be consistent with the expression "a wall of the outer tube", the term "saki" was changed to "the".

2) The Examiner objected to the page numbers of the claims for not complying with subsection 73(1) of the *Patent Rules*, specifically alleging that the description ends on page 16 while the claims being on page 11. In response to this objection, the page numbers of the claims have been changed from 11-16 to 17-22, thereby overcoming this objection.

SUMMARY

Any amendments and observations contained herein are made solely for the purposes of the prosecution of this Canadian patent application and are without prejudice to the Applicant in other jurisdictions. The Applicant has endeavoured to be fully responsive to all of the Examiner's concerns and believes that the application, as amended, is now in condition for allowance. The Applicant respectfully solicits allowance of the amended application as enclosed herein.

General payment authorization:

Should the fees submitted with this letter be insufficient to cover all of the fees for which payment is explicitly or implicitly requested by this letter and indication of the intent of the owner to maintain this matter in good standing, CIPO is authorized to charge the amount of the insufficiency using the deposit account or credit card payment methods specified in the accompanying Fee Payment Form.

All of which is respectfully submitted.

Yours very truly,

MLT AIKINS LLP

Scott E. Davidson Agent No. 11495
/AML/yyw

Encl.

Date Reçue/Date Received 2022-02-23

CLAIMS

1. A superheater element for superheating steam within a firetube of a firetube boiler comprising:

an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube; and

a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube.

2. A superheater element of claim 1 wherein said interior face of said return is described as the bottom-half of the surface of a horn torus wherein the axis of rotational symmetry of said horn torus is the central axis shared by said outer and inner tubes.

3. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving a parabola in a three-dimensional space about an axis of rotation that intersects with said parabola and is parallel with the axis of symmetry of said parabola wherein said axis of rotation is the central axis shared by said outer and inner tubes.

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4. A superheater element of claim 1 wherein said interior face of said return has a surface described by a portion of the surface of revolution generated by revolving one branch of a hyperbola in a three-dimensional space about an axis that intersects with said hyperbola branch and is parallel with the axis of symmetry of said hyperbola branch, wherein said axis of rotation is the central axis shared by said outer and inner tubes.

5. The superheater element of claim 1 wherein said boiler has a burner end opposite an exhaust end and said superheater element extending within said boiler from the burner end to the exhaust end.

6. The superheater element of claim 1 wherein the wall of the inner tube is shaped and sized to maximize the thermal conductivity between the inner and outer tubes, giving consideration to the tube material, and the pressure and temperature of the superheated steam flowing through said inner and outer tubes.

7. The superheater element of claim 1 wherein said inner and outer tubes are fabricated from material selected from a group consisting of carbon steel, stainless steel, and steel comprising chromium, molybdenum, and manganese alloys.

8. The superheater element of claim 1 wherein said return is fabricated from erosion resistant material comprising heat treated high carbon alloy steels.

9. The superheater element of claim 1 wherein said return is fabricated from erosion resistant material comprising turbine blade material.

10. The superheater element of claim 5, wherein saturated steam introduced into said inlet manifold gains heat energy while traveling along the outer tube towards the exhaust end of said boiler, is directed into said inner tube by said return, and then loses heat energy to the saturated steam within said outer tube while traveling within said inner tube towards the burner end of said boiler before exiting the outlet manifold.

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11. A method for superheating steam using a superheater element inserted into the firetube of a firetube boiler, said boiler having a burner end opposite an exhaust end, comprising the steps of:

providing a superheater element having an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube; and

a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube introducing saturated steam into said inlet manifold of said element;

causing said steam to travel within the outer tube towards the exhaust end of said boiler while absorbing heat energy from heated firetube gasses through a wall of the outer tube;

directing said now superheated steam into said inner tube by means of said return; causing said superheated steam to travel within the inner tube towards the burner end of said boiler while losing heat energy to said saturated steam in said outer tube through a wall of the inner tube; and

causing said superheated steam to exit said outlet manifold.

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12. A method for retrofitting firetube boilers to superheat steam comprising the steps of:

(a) providing one or more superheater elements each comprising an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube and a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube;

(b) providing an existing firetube boiler; and

(c) inserting said superheater elements into one or more firetubes of the existing firetube boiler.

13. The method of claim 12 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently compared with before the retrofit, by reducing the heat loss from the superheated steam to the boiler.

14. A method for retrofitting firetube boilers to superheat steam comprising the steps of:

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(a) providing one or more superheater elements each comprising an outer tube concentric about an inner tube, said outer and inner tube each having a return end and a non-return end;

an inlet manifold connected to the non-return end of said outer tube;

an outlet manifold connected to the non-return end of said inner tube; and

a return affixed to the return end of said outer tube, said return having an interior face and a central axis parallel to and shared by the inner and outer tubes;

wherein the interior face of said return is rotationally symmetric at all angles of rotation about the central axis; and

wherein a point of said interior face is raised towards the return end of said inner tube along said central axis without extending into the inner tube;

(b) providing an existing firetube boiler;

(c) providing one or more choke thimbles;

(d) inserting said superheater elements into one or more firetubes of the existing firetube boiler; and

(e) inserting a choke thimble into each firetube of the existing firetube boiler.

15. The method for retrofitting firetube boilers to superheat steam of claim 14, wherein only some of the firetubes have superheater elements and choke thimbles are used on only the firetubes that do not have superheater elements.

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16. The method of claim 14 wherein said firetube boiler already produces superheated steam and is retrofitted to superheat steam more efficiently compared with before the retrofit, by reducing the heat loss from the superheated steam to the boiler.

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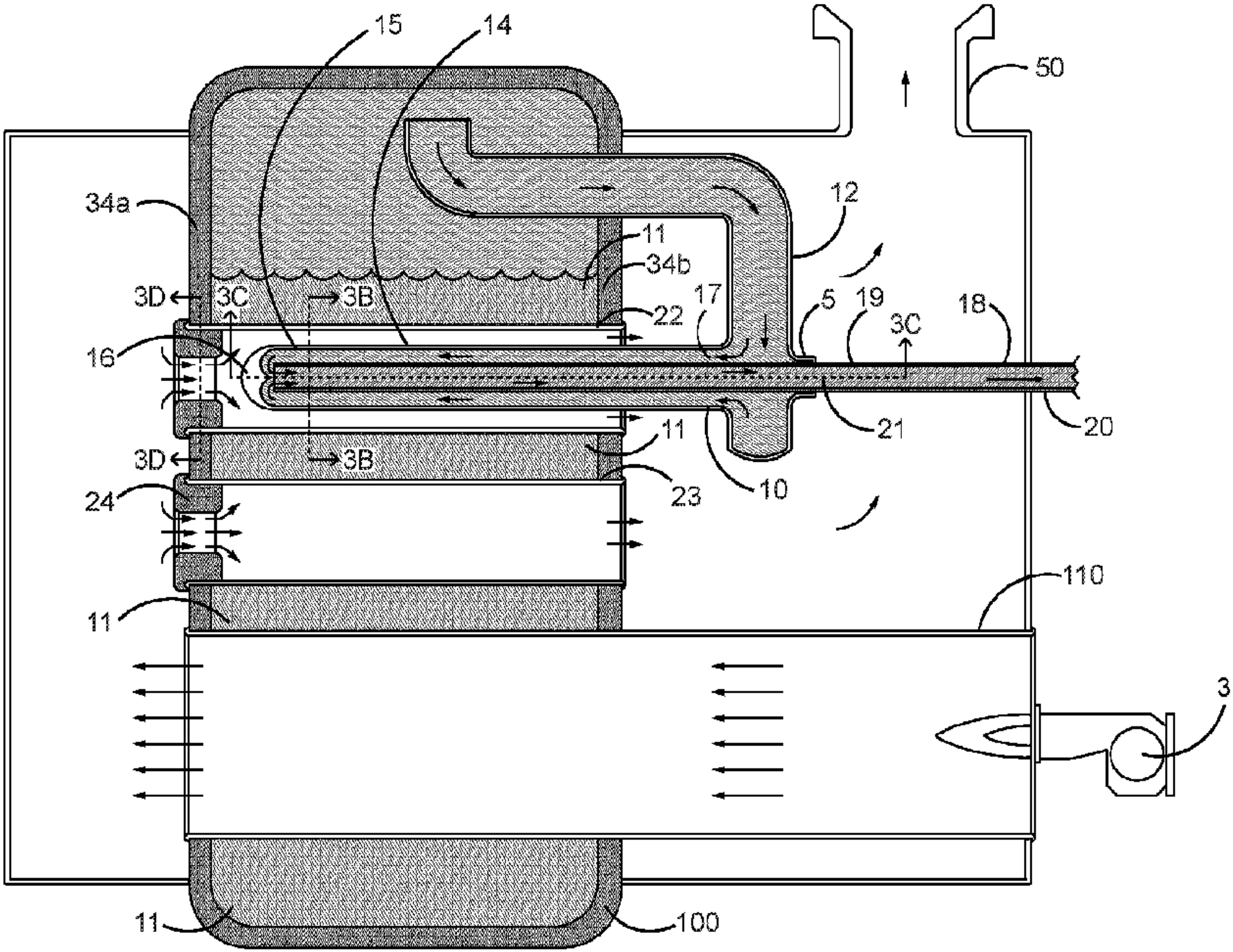
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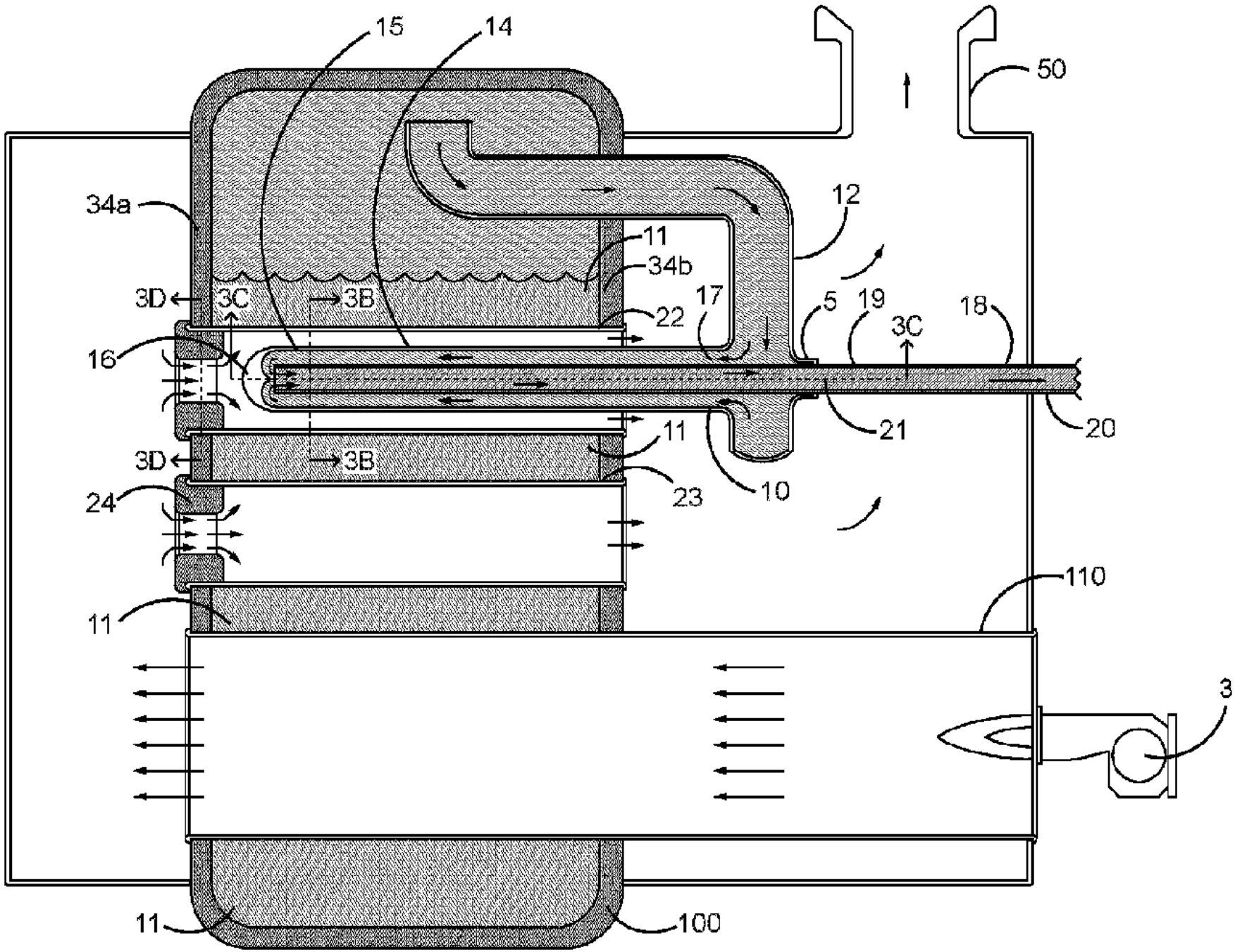
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FIG. 3A