Feb. 18, 1958 L. J. MARSHALL 2,823,651

PACKAGE BOILER USING CONTROLLED CIRCULATION

Filed Dec. 30, 1954 5 Sheets-Sheet 1

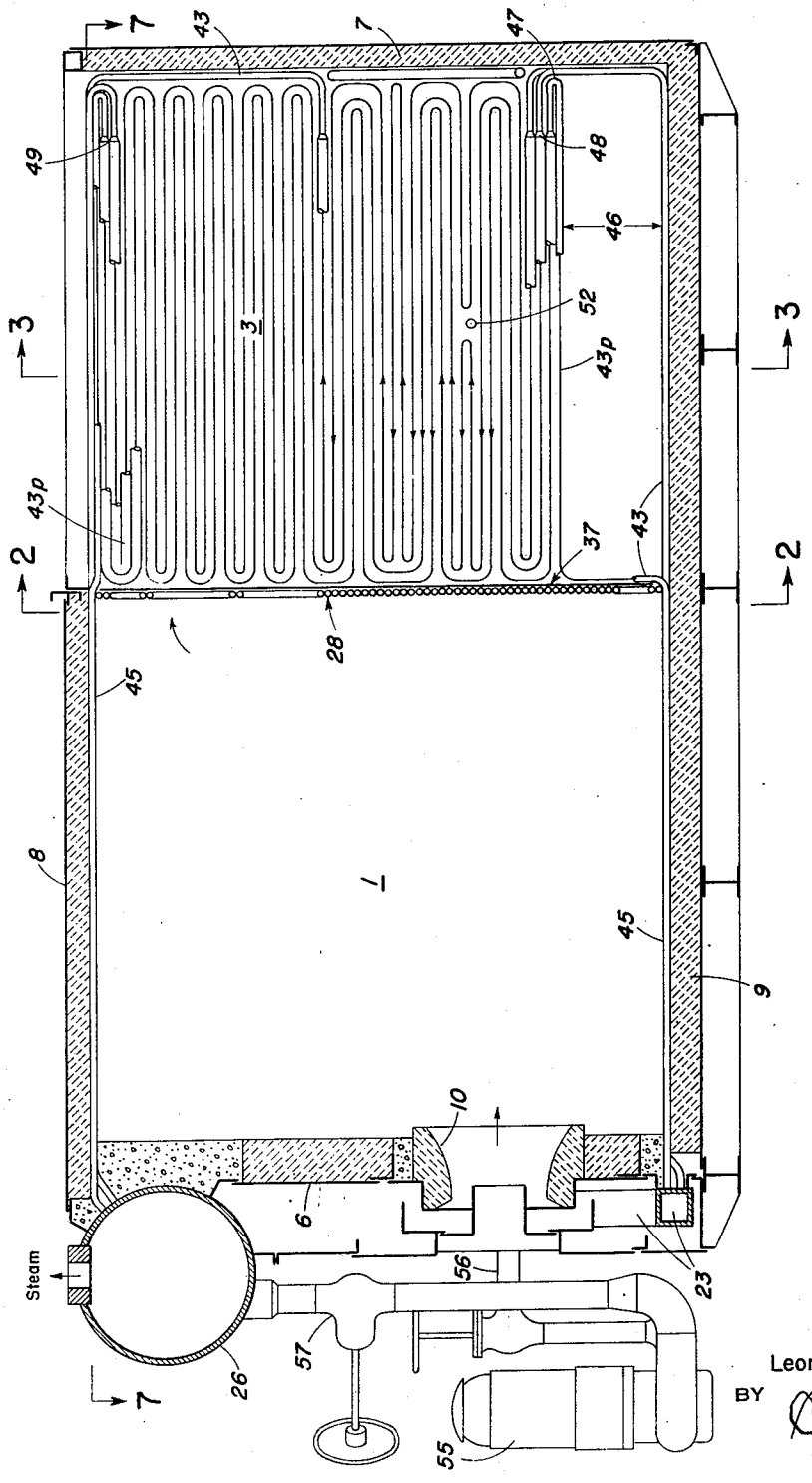


Fig. 1.

INVENTOR
Leonard J. Marshall
BY C. J. Bryant
ATTORNEY

PACKAGE BOILER USING CONTROLLED CIRCULATION

Filed Dec. 30, 1954 5 Sheets-Sheet 2

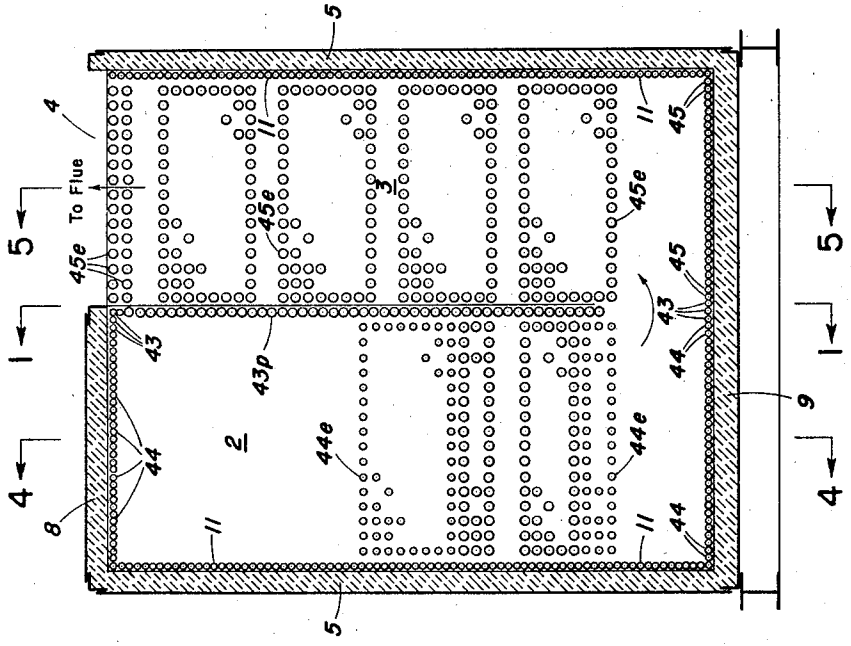


Fig. 3.

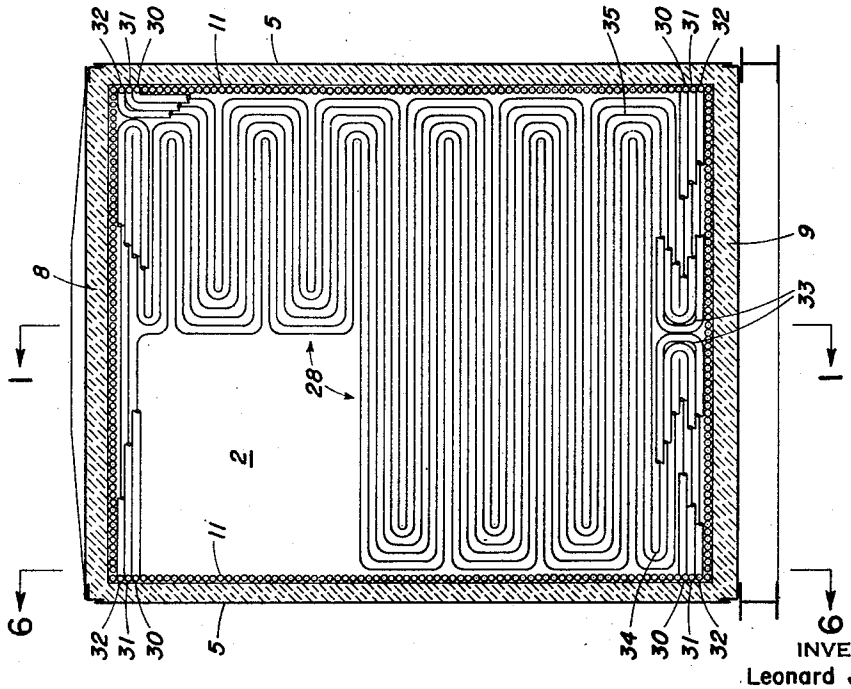


Fig. 2.

INVENTOR
Leonard J. Marshall
BY
ATTORNEY

Feb. 18, 1958 L. J. MARSHALL 2,823,651

PACKAGE BOILER USING CONTROLLED CIRCULATION

Filed Dec. 30, 1954 5 Sheets-Sheet 3

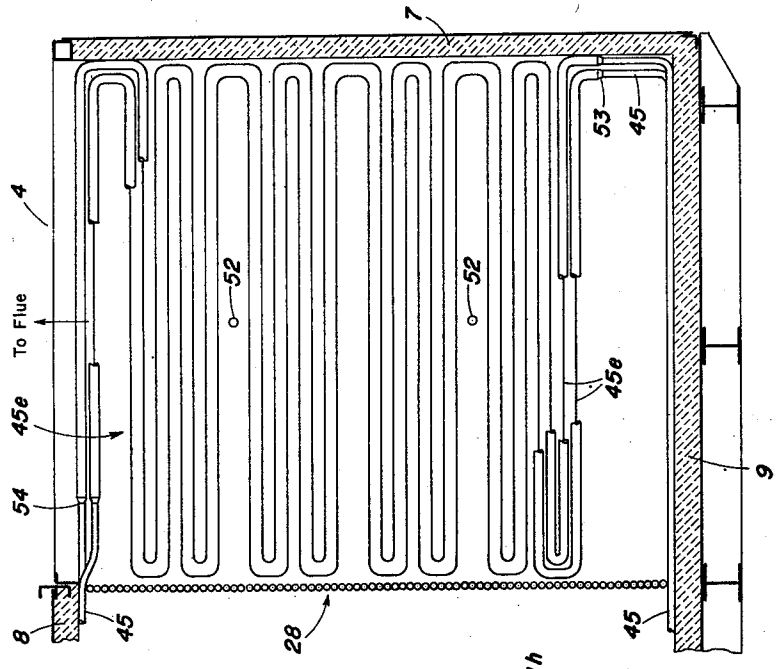


Fig. 5.

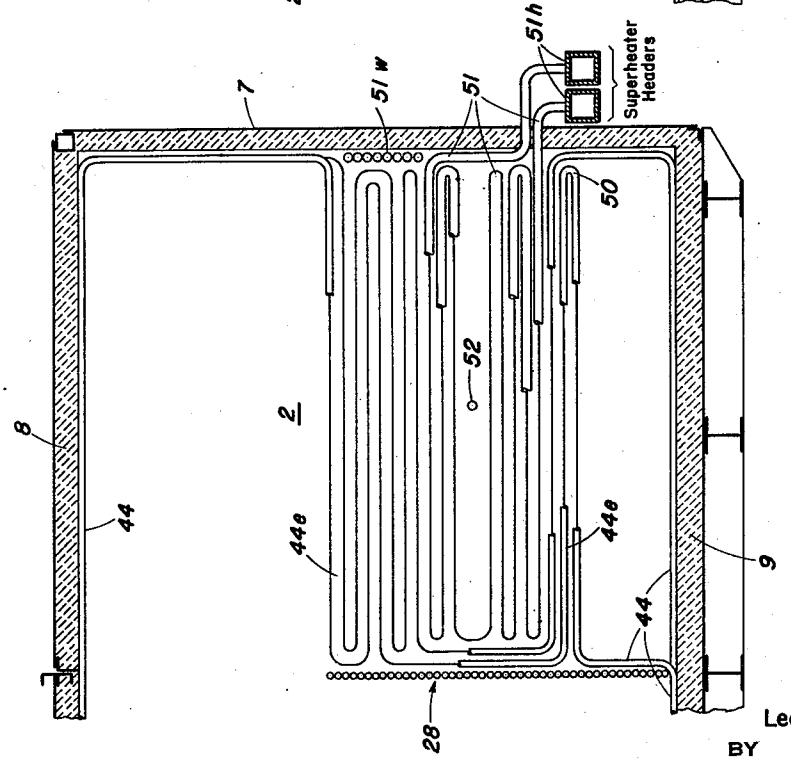


Fig. 4.

INVENTOR
Leonard J. Marshall
BY
ATTORNEY

Feb. 18, 1958 L. J. MARSHALL 2,823,651

PACKAGE BOILER USING CONTROLLED CIRCULATION

Filed Dec. 30, 1954 5 Sheets-Sheet 4

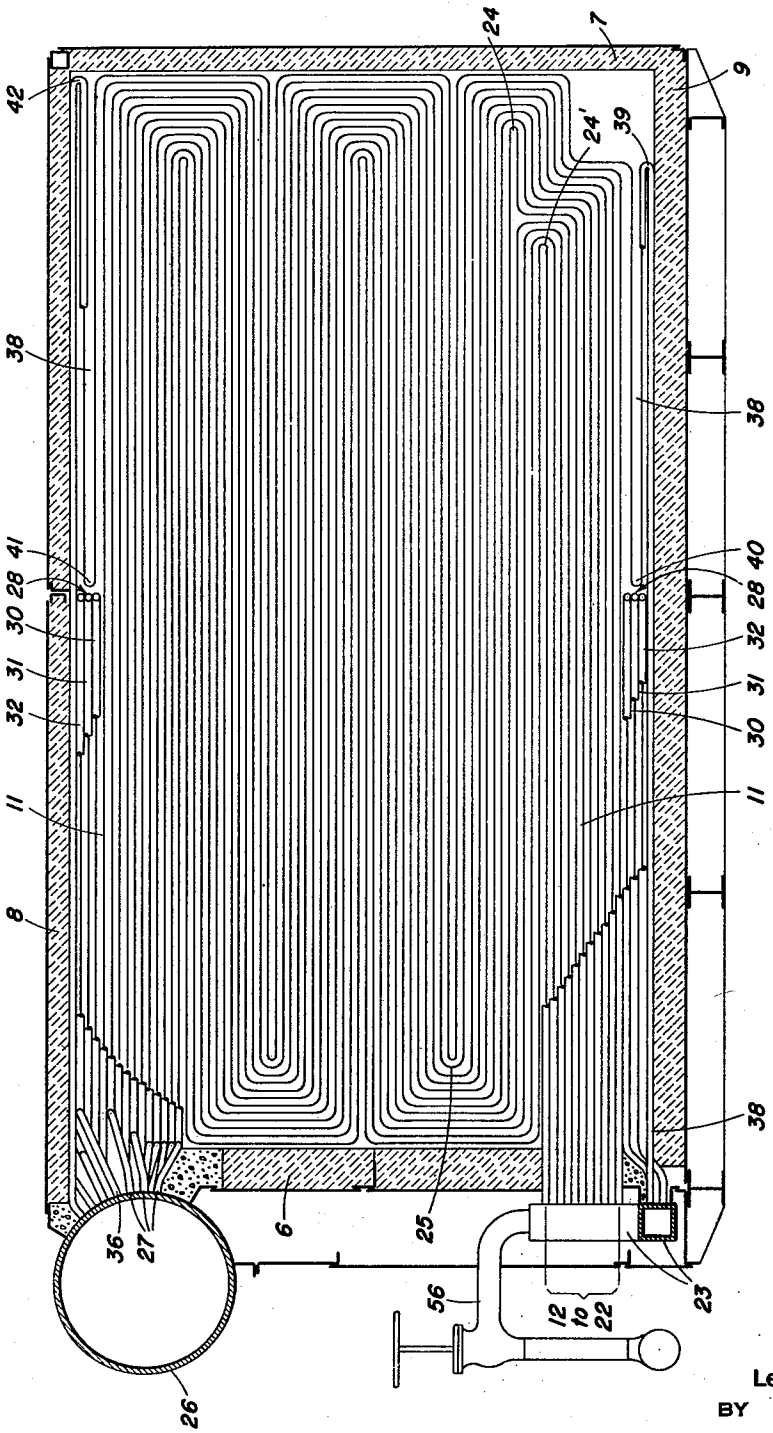


Fig. 6.

INVENTOR
Leonard J. Marshall
BY
ATTORNEY

Feb. 18, 1958 L. J. MARSHALL 2,823,651

PACKAGE BOILER USING CONTROLLED CIRCULATION

Filed Dec. 30, 1954 5 Sheets-Sheet 5

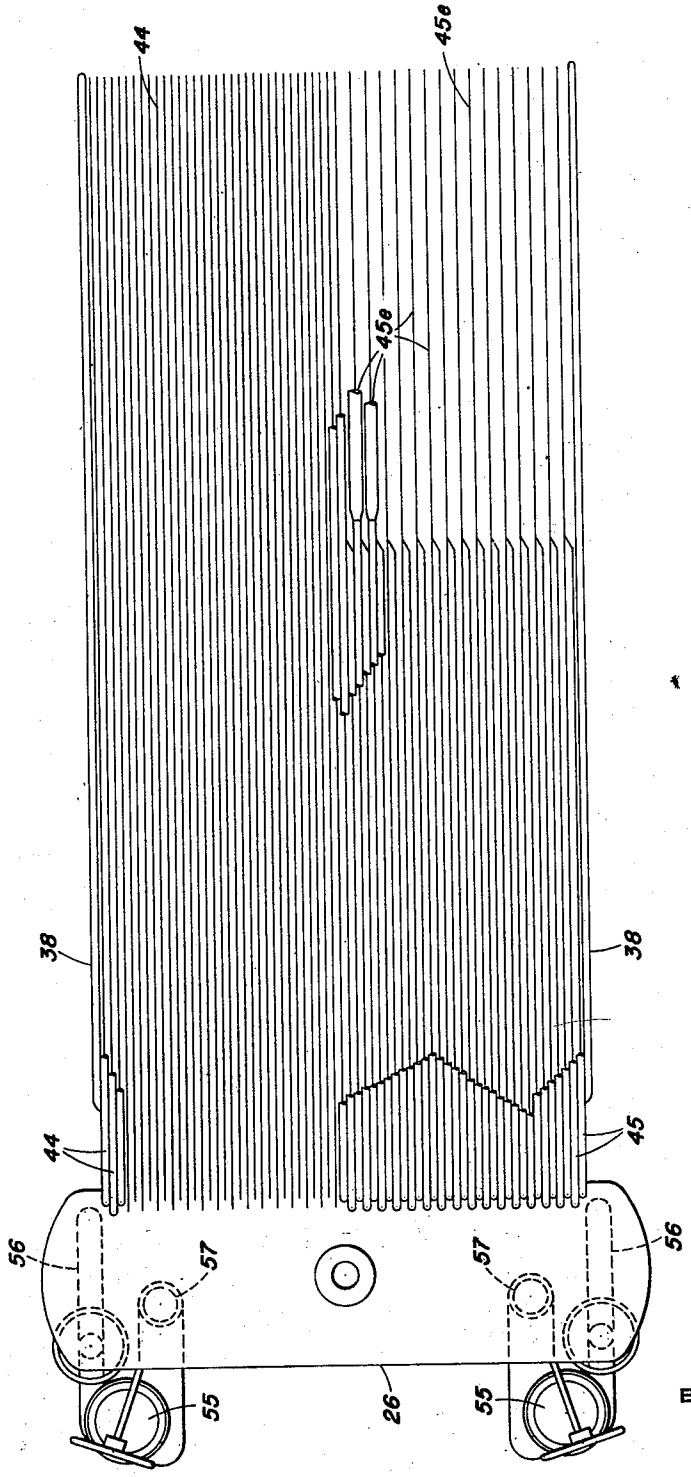


Fig 7

INVENTOR
Leonard J. Marshall
BY R. F. Bryant
ATTORNEY

United States Patent Office 2,823,651 Patented Feb. 18, 1958

2,823,651

PACKAGE BOILER USING CONTROLLED CIRCULATION

Leonard J. Marshall, Tenafly, N. J., assignor to Combustion Engineering, Inc., New York, N. Y., a corporation of Delaware

Application December 30, 1954, Serial No. 478,783

3 Claims. (Cl. 122—235)

This invention relates to boilers for the generation of steam and particularly to the so-called "package boiler" which is assembled in the shop and shipped to the user as an assembled unit.

Generally stated the object of this invention is to provide for such package boilers a novel organization and arrangement of parts which combines design simplicity with maximum space utilization and which boosts the obtainable steaming capacity.

A more specific object is to raise the upper limit in steaming capacity for package boilers whose physical dimensions are restricted by such factors as the size of railroad shipping cars.

Another object is to simplify package boiler construction from the standpoint of shop fabrication and quantity production; also to provide a design which is adaptable to medium and small capacities as well as to large capacities.

A further object is to provide such boilers with improved water circuits which individually incorporate both furnace water cooling surface and convection heat absorbing surface.

An additional object is to incorporate into such boilers improved baffling which eliminates refractory and which serves as steam generating surface.

Still further objects and advantages will become apparent as the disclosure and description hereof proceeds.

In practicing this invention the foregoing objects and advantages are achieved by utilizing heating elements or circuits through which the water to be evaporated is forced in controlled amounts. Circulation of water through these heating circuits is accomplished by one or more pumps and a plurality of circuits are connected to the pumps in parallel for discharge of the water and steam mixture into a steam and water separating drum from which the generated steam is withdrawn to a point of use. Individual circuits in this parallel group incorporate both furnace water cooling surface and convection heat absorbing surface; and these and other elements of the boiler are arranged, constructed and combined in novel and unique manner which attains the results desired as hereinafter set forth.

An illustrative embodiment of this invention is shown by the accompanying drawings wherein:

Fig. 1 is a vertical longitudinal cross section, taken on line 1—1 of Figs. 2 and 3, through a steam generating unit constructed in accordance with the invention.

Figs. 2, 3, 4 and 5 are vertical transverse sections taken respectively on lines 2—2 and 3—3 of Fig. 1 and on lines 4—4 and 5—5 of Fig. 3.

Fig. 6 is a vertical longitudinal cross section taken on line 6—6 of Fig. 2 showing a typical side wall elevation.

Fig. 7 is a top plan view of the roof of the steam generator taken on line 7—7 of Fig. 1.

The illustrative steam generating unit here shown comprises a furnace portion 1 (Fig. 1) and a furnace offtake passage 2, 3 (Figs. 1, 2, 3) through which the products of combustion from the furnace flow first downwardly through passage 2 thence across and upwardly through passage 3 to leave the generator through outlet 4 (Fig. 3). Side walls 5 (Figs. 2–3), front and rear walls 6 and 7 (Figs. 1 and 6), roof and bottom walls 8 and 9 (Figs. 1–6) enclose the unit.

One or more burners 10 deliver fuel and air mixture into the furnace 1 through the front wall 6. These burners 10 may be suitable for burning fuel oils of a wide variety of grades; or they may be designed for such other fuel as it is desired to use.

The steam and water drum 26 of the boiler extends along the front wall 6 outside its upper edge. Water from the lower portion of this drum passes into one or more pumps 55 (two are shown here—see Fig. 7) which serve to circulate the water first into an inlet header 23 and thence in controlled amounts through the various steam generating circuits of the boiler. The inlet header 23 has a horizontal portion that spans the boiler width along the lower edge of front wall 6 plus left and right upright end portions into which the left and right pumps 55 (see Fig. 7) respectively feed via discharge pipes 56 (see Figs. 1 and 6).

Every one of the parallel steam generating circuits in the boiler begins in this inlet header 23 and ends in the boiler drum 26; these parallel circuits individually incorporate both furnace water cooling surface and convection heat absorbing surface; and one circuit generally representative of this entire parallel group extends from header 23 along the bottom of furnace 1, thence along the floor of offtake passages 2—3, thence sinuously up through one of those passages to provide convection surface, thence along the roof of offtake passages 2—3, thence along the roof of furnace 1 and finally into drum 26.

All of these parallel steam generating circuits similarly discharge directly into drum 26 (see Figs. 6–7); and said circuits have the various individual locations and characters now to be described.

The circuits which line the boiler side walls 5 will first be considered. Those left and right side walls 5 are symmetrically the same and each is shown by Figs. 2, 3 and 6 as extending for the full length of the furnace 1 and of the offtake passage 2, 3 and as being lined with groups of steam generating tubes formed into panels generally designated as 11. The tubes making up each of these two side wall panels 11 are designated in Fig. 6 as 12 to 22, 30—31—32 and 38; and these tubes originate at the panel bottom where they are connected into inlet header 23 for reception of boiler water therefrom.

The water supply tubes 12 to 22 in each of these side panel groups thence extend rearwardly in parallel along their wall 5 and horizontally to the rear wall 7 where they are formed into return bends 24—24' as shown by Fig. 6, thence extend horizontally forwardly in parallel to the front wall 6 thence through return bends 25 and continue in similar back and forth upward paths as shown until they have substantially covered the side wall 5. They finally connect into the steam and water drum 26 through bends into tube holes shown at 27.

Each of these two side wall panels 11 (left and right in Fig. 2) includes the earlier mentioned bottom tube 38 (Fig. 6) which extends from inlet header 23 rearwardly through the furnace 1 and the offtake passage 2—3 toward the rear boiler wall 7, thence through a return bend 39, thence forward within the offtake passage 2—3 to the furnace's rear wall 28 (Figs. 1 and 6), thence through another return bend 40, thence rearward where it joins the group of side wall tubes 12 to 22 to pass with them in parallel alignment back and forth and upwardly as previously described to a location adjacent the roof 8.

The bottom loops of tube 38 including return bends 39

and 40 cover the side wall 5 rearward of the furnace's rear wall 28 (later to be described) where the tubes 30, 31, 32 turn into said wall. Similarly the top loops of tube 38 including return bends 41 and 42 cover the side wall 5 in the offtake passage 2, 3 where tubes 30, 31, 32 turn out of the furnace's said rear wall 28. The uppermost extension of tube 38 passes along the top of each side wall panel 11 and connects into the steam drum 26.

Attention will next be directed to the rear boundary of furnace 1. This boundary takes the form of a wall represented at 28 in Figs. 1, 2 and 6 and which is made up of steam generating tubes disposed as shown in a flat panel that has opening 2 in its upper left portion (Fig. 2). The tubes constituting this wall 28 originate in the aforementioned left and right groups 30, 31, 32 with the three tubes in each group being connected into the inlet header 23 for reception of boiler water therefrom. One such group of tubes is disposed along the lower edge of each of the two side walls 5 as Figs. 2 and 6 show. From the water supply header the tubes 30, 31, 32 in each group extend rearwardly in parallel and horizontally along the face of the furnace side wall 5 to the furnace's rear wall 28; and it will be seen that these tubes 30, 31, 32 are in the same plane as the side wall tubes 12 to 22 immediately thereabove.

At the location of the furnace's said rear wall 28 the tubes 30, 31, 32 from each side wall 5 bend into the plane of the wall (Figs. 6, 2) thence extend horizontally inwardly and in parallel to the middle of said wall where they are formed into return bends 33 (Fig. 2), thence extend outwardly in parallel and horizontally to the side walls 5 and through return bends 34 and 35 (Fig. 2). Return bends 35 are of greater depth than the bends 34 so that the horizontal extensions of the tubes 30, 31, 32 from return bends 35 will overlie the extensions of the tubes from return bends 34 within the plane of said rear furnace wall 28. The tubes 30, 31, 32 thence continue in back and forth and upward paths as shown until they cover the entire wall 29 except for the opening constituting the offtake passage 2 shown at the upper (Fig. 2) left of the drawing.

These tubes 30, 31, 32 continue upwardly constituting the right upper portion of furnace wall 28 (Fig. 2) and at the wall top they separate into left and right groups as shown. Then bending forwardly these two groups fall into the planes of the left and right side wall tubes 11 as indicated at 30, 31, 32 in Figs. 2 and 6. From this point they extend further forwardly in alignment with said side wall tubes and finally connect into the drum 26 through bends into the tube holes shown at 36 (Fig. 6).

Along the rearward side of the furnace's rear wall 28 a plate preferably is provided in the location designated 37 in Fig. 1. Purpose of such a plate is to supplement the side-by-side arranged tubes 30, 31, 32 in confining furnace combustion gases ahead of the wall 28 throughout all of the wall area except the gas outlet 2 through the wall's upper left portion (Fig. 2).

Attention will now be turned to the convection heat absorbing facilities of the boiler which are positioned to the rear of said furnace wall 28 (see right portion of Fig. 1). Said facilities include the earlier mentioned offtake passes 2 and 3 and also a partition wall which is shown at 43*p* in Figs. 1 and 3 and which serves to separate these two passes. Disposed within these separated offtake passes 2 and 3 in the manner indicated by Figs. 3, 4 and 5 are banks of heat absorbing elements 44*e* and 45*e* later to be described.

The partition wall 43*p* just named extends down from the boiler roof 8 to an elevation spaced above the boiler floor 9 by a distance shown at 46 in Fig. 1 and also indicated by Fig. 3. It is formed by groups of three tubular circuits designated 43 in Fig. 3 which emanate from the boiler offtake floor as Fig. 1 shows and which pass back and forth upwardly through the wall plane and thence into the boiler offtake roof.

One of these three tube circuits 43 in partition 43*p* rises upward from floor 9 just beyond the furnace's rear wall 28 for the height of said spaced distance 46, thence bends to the horizontal to form the bottom tube of the partition 43*p* and then passes through a return bend 47. The tubes of the two remaining circuits 43 continue along the offtake floor 9 and rise upwardly along the rear wall 7 and thence bend forwardly above the bend 47 of the one circuit 43 and into alignment therewith. Thereafter the three tubes of the circuits 43 follow a back and forth sinuous path across the offtake passage 3 as shown, within the plane of the partition 43*p* and in parallel contacting relation whereby a substantially gas tight partition is formed.

As shown in Fig. 1, one of these circuits 43 may have its upper portion arranged to rise upwardly along the face of the rear boiler wall 7 to the roof 8 while the remaining two continue in a sinuous path to the roof 8. Beneath the roof 8 above offtakes 2 and 3 the three tubes of the three circuits 43 again bend into alignment in a horizontal plane just before passing forwardly into the furnace 1.

As also shown in Fig. 1, the three circuits 43 preferably have their tubes enlarged between locations 48 and 49. Such enlargement serves the useful purpose of providing more internal tube space for the generation of steam due to heat absorbed by the tubes from which said partition wall 43*p* is formed. It also increases the area of convection heat absorption surface.

Obviously the two passes here shown at 2 and 3 in the offtake for the combustion gases leaving furnace 1 may if desired be replaced by only a single pass. But in most instances the two-pass arrangement here illustratively disclosed will be found to be advantageous and preferable. The convection steam generating surface 44*e* and 45*e* used in said passes will now be described.

These convection heat absorbing elements 44*e* and 45*e* disposed in the separated offtake passes 2 and 3 of the boiler are formed by a multiplicity of groups of two tubular circuits 44 and 45 respectively. These groups of circuits each comprise horizontally adjacent tubes connected into the inlet header 23 which thence extend rearwardly in parallel contact across the furnace floor 9, thence through the furnace's rear wall 28 into the offtake passes 2, 3 where they are arranged to form the partition 43*p* and the banks of convection elements 44*e* and 45*e*; thence these tubes extend from the partition 43*p* and element banks 43*e* and 45*e* forwardly along the roof 8 of the furnace in horizontal parallel contact to enter the steam drum 26.

Each of the steam generating circuits forming the partition 43*p* or forming an element 44*e* or 45*e* is disposed substantially within a plane parallel to the boiler side walls 5. These circuits in passing through the furnace along the floor or roof are in horizontal alignment and one of the circuits of each group may lie within the vertical plane through the partition or through an element while the other circuit or circuits align with and contact said one circuit. Each circuit of a group is therefore disposed throughout its length within or is closely aligned with one of a multiplicity of spaced planes disposed between and parallel to the said side walls 5 of the boiler.

As shown in Figs. 3 and 4, the adjacent furnace floor tubes of two circuits 44 are arranged to form the sinuous tubular heat absorbing element 44*e* in the offtake pass 2. Fig. 4 indicates how one of these tube circuits 44 rises upwardly from the floor just beyond the furnace's rear wall 28 to a height about on a level with the bottom of partition 43*p*, thence bends to the horizontal to form the bottom tube of the element 44*e* and then passes through a return bend 50; also how the tube of the adjacent circuit 44 continues across the offtake floor and rises upwardly along the boiler's rear wall 7, thence bends for-

wardly above the one circuit 44 and into alignment therewith. Thereafter the tubes of the two circuits 44 follow a back and forth sinuous path across the offtake passage 2 in loops as shown forming element 44*e* within a plane parallel to the side walls 5 up to the level of the bottom of the opening from the furnace 1 into the offtake passage 2. At this level the two circuits rise to the roof 8 along the face of the boiler's rear wall 7 and thence extend forwardly in horizontal alignment beneath the roof of the offtake pass 2 and of the furnace 1 to connect into the steam drum 26.

If desired a superheater 51 may be inserted between portions of the elements 44*e* as shown in Fig. 4. In this case some of the loops of the steam generating tubes 44 are vertically spaced apart to provide the necessary space for the superheater as shown; and generated steam leaving boiler drum 26 can be admitted into superheater 51 and withdrawn therefrom via headers 51*h*. Moreover, superheater tubes 51*w* may be used to face the boiler's rear wall 7; and when so used these facing tubes 51*w* can be included in the steam flow circuit of superheater 51.

The convection surfaces 45*e* in boiler pass 3 will now be described. Figs. 3 and 5 show that the adjacent floor tubes of two circuits 45 are arranged to form a sinuous tubular heat absorbing element 45*e* in offtake pass 3, in the same manner as the elements 44*e* are formed in offtake pass 2 from adjacent floor tube circuits 44 and as described. In this pass 3, the tubular elements 45*e* extend up to the roof 8 of the pass, thence extend forwardly along the roof to the rear furnace wall 28 in vertical alignment where the two tubes bend into horizontal alignment and thence extend beneath the roof of the furnace to connect into the steam drum 26. In both the elements 44*e* of pass 2 and the elements 45*e* of pass 3, certain loops may be spaced apart, as shown, to permit the insertion of soot blowers indicated at 52 in each of Figs. 4 and 5.

Preferably the tubes of elements 45*e*, like the tubes of the partition 43*p*, are enlarged between locations 53 and 54 in the manner indicated by Fig. 5. Such enlargement serves the purpose of decreasing the free area between the tubes of the elements 45*e* thereby increasing the mass flow of the products of combustion therebetween and increasing the heat transmission to the tubes. It also reduces the resistance to the flow of fluid within the tubes whereby the total resistance of the associated circuits may be decreased to effect an approach of the resistances of these circuits to those of the remaining circuits of the generator.

It may be pointed out that in operation the pressure drop or resistance of each water circuit of the generator from the inlet header 23 to the steam drum 26, including any inlet resistance or orifice present (no orifices are shown here), is chosen to be substantially the same as that of any other circuit; that the various circuits are so constructed that said selected resistance will during normal operation of circulating pumps 55 assure maintenance in every circuit of a ratio of water to steam which is adequate to assure safe tube temperature throughout the circuit; and that the foregoing conditions frequently can be achieved if there is placed in each circuit an inlet orifice which has the same size as the orifice for any of the other circuits.

Looking again at Fig. 4, it will be seen that the convection elements 44*e* in offtake pass are all duplicate and that this duplication includes the two adjacent floor and roof circuits 44, 44 which extend through the furnace 1 and serve as entrance and exit connections to each element respectively from the inlet header 23 and the steam drum 26. The elements 45*e* in offtake pass 3 (Fig. 5) are similarly duplicate and the duplication to each element includes the two adjacent connected floor and roof circuits 45, 45 which extend through the furnace to the inlet header 23 and to the steam drum 26. The number of different circuit patterns for the elements 44*e*, 45*e*, the side walls 11 and the partition 43*p* is therefore reduced to a relative few and all circuits with the exception of the rear furnace wall 28 are bent in substantially one plane only. This is a marked advantage when considering fabrication and storage of the parts and the easy removal of the elements either thru the rear wall 7 or thru the roof 8 of the boiler.

It further is to be noted that the tubes of the convection elements 44*e* and 45*e* lie in spaced parallel vertical planes providing straight lanes between the tubes of the elements for inspection and lancing for dirt removal if required. Since the furnace gas outlet into the offtake pass 2 preferably does not contain any heat absorbing surface, the open space above the first convection bank of elements 44*e* (Fig. 4) serves as combustion space and can be considered a portion of the furnace. Moreover, the convection heating surfaces are omitted below the level of the bottom of partition 43*p* (see Fig. 3).

The new controlled circulation package boiler here illustrated and described offers a number of advantages which are highly practical. Certain of these advantages have already been indicated and others will now be mentioned.

There is but one fluid inlet header 23 which supplies all of the circuits in the steam generator. This single header 23 preferably is located outside of the front furnace wall 6 and within the boiler casing in the manner which Figs. 1 and 6 indicate. This construction minimizes the number of seals required against gas leakage from the furnace into the boiler room. Also the steam drum 26 is located at the top of the front wall 6 and extends crosswise of the unit with its top at or below the level of the roof 8 of the generator. In shipment this limits the drum clearance to that of the generator.

Looking next at the circulation pump or pumps 55, these are located adjacent the inlet header 23 and are connected thereto via the very short piping shown at 56 in Figs. 1 and 6. Moreover, the suction lines 57 that connect the pumps 55 into the steam and water separating drum 26 adjacent the drum ends are likewise direct and short. The arrangement disclosed permits the pumps 55 to be disconnected for shipment; and this desirably reduces the overall shipping length of the package boiler unit.

Since this new package boiler, including the walls of the furnace and offtake passage and all the contained circuits, is fabricated and assembled in the shop and is shipped as an assembled unit, the largest unit shippable by railroad will have a length limited to fit onto a freight car (such as of the depressed flat type) and its permissible height and width will be established by the clearance limitations when mounted on such a car. Because of the improved design of the unit as described above and the utilization of small tubes in all circuits, exceptionally high steaming capacities are achieved within the aforesaid limiting dimensions imposed upon it.

Consider, for example, a unit using in all circuits 1½" tubes which enlarge to 2" tubes for the partition wall 43*p* and for the convection heating surfaces 44*e* and 45*e* in the offtake passes, with the tubes contacting in the furnace, in the side walls and in the partition wall and spaced horizontally on 3⅛" centers within the offtake passes. Such a unit physically dimensioned for shipment on a railroad freight car can generate up to about 80,000 pounds of steam per hour at pressures up to about 475 p. s. i. This is substantially double the prior top capacity (about 40,000 pounds of steam per hour) for assembled package boilers that have been shippable on railroad cars in the past.

Moreover, when compared with compact steam generators of equal capacity using the natural circulation designs of the past, this improved controlled circulation package boiler unit occupies less than about half the space and weighs only about one third.

And finally, the new controlled circulation unit is adaptable to standardization in sizes ranging from a rating of

about 6000 to as high as 80,000 pounds of steam per hour. Sizes vary with the number of elements in width, their height and depth and the furnace dimensions; the general design remaining substantially the same as disclosed. Drum lengths are maintained relatively short. Available space is fully utilized in the design; wherefore there is practically no waste space.

While one preferred embodiment of the invention has been shown and described, it will be understood that such disclosure is illustrative rather than restrictive and that changes in construction, combination and arrangement of parts may be made without departing from the spirit and scope of the invention as claimed.

What I claim is:

1. In a steam generator of the package boiler type that is adapted to be assembled in the shop and to be shipped as an assembled unit, the combination of left and right side walls plus floor and roof walls and front and rear walls organized to define an enclosed space, said space including a forward furnace portion that extends rearwardly from said front wall and a rear gas pass portion that extends forwardly from said rear wall, burner means for bringing fuel into said furnace space along with air to support combustion of the fuel, means forming in the rear portion of said roof a first opening which communicates with one side of said gas pass space and through which first opening combustion gases can discharge from that space, a steam and water drum disposed along the upper portion of said front wall in spanning relation thereto, a water distributing header disposed along the lower portion of said front wall in spanning relation thereto, circulating pump means for receiving water from the lower portion of said drum and for forcing it into said distributing header, steam generating circuits made up of tubes that extend in parallel from said bottom header along the floor of said furnace space and of said gas pass space so as to line that floor and thence in spaced sinuous relation upwardly through said gas pass space to form convection heat absorbing surface therein and thence in parallel along the gas pass roof area so as to line that area exclusive of said first opening and further along the furnace space roof so as to line that roof and thence into said upper drum, other steam generating circuits made up of further tubes that line each of said left and right side walls and that are connected with said lower header to receive circulating water therefrom and with said upper drum to discharge steam and water mixture thereinto, and a transverse partition wall disposed between said forward furnace space and said rear gas pass space and serving to confine flow of combustion gases out of the furnace space to a second opening through that transverse partition which is opposite said first opening in the gas pass roof, said transverse partition wall being formed from parallel steam generating tubes which are sinuously bent back and forth in the plane of the transverse partition and which are connected with said water distributing header at their lower ends and with said steam and water drum at their upper ends, said transverse partition wall having said second opening therethrough located in the upper area of the partition wall and wherein there is provided between the left and right portions of said rear gas pass space a longitudinal partition which is disposed along one edge of said first opening in the gas pass roof and which extends downwardly from said roof to a point spaced above the gas pass floor, said longitudinal partition separating the said convection heat absorbing surface on the longitudinal partition's left side from the said convection heat absorbing surface on the longitudinal partition's right side with the result that hot combustion gases entering the rear gas pass space through said upper second opening in the aforesaid transverse partition wall are directed downwardly over the convection heat absorbing surface on the gas entering side of said longitudinal partition thence beneath that longitudinal partition and thence upwardly over the convection heat absorbing surface on the gas leaving side of that longitudinal partition and finally out of the rear gas pass space by way of said first opening in the gas pass roof.

2. In a steam generator of the package boiler type that is adapted to be assembled in the shop and to be shipped as an assembled unit, the combination of left and right side walls plus floor and roof walls and front and rear walls organized to define an enclosed space, said space including a forward furnace portion that extends rearwardly from said front wall and a rear gas pass portion that extends forwardly from said rear wall, burner means for bringing fuel into said furnace space along with air to support combustion of the fuel, means forming in the rear portion of said roof a first opening which communicates with one side of said gas pass space and through which first opening combustion gases can discharge from that space, a steam and water drum disposed along the upper portion of said front wall in spanning relation thereto, a water distributing header disposed along the lower portion of said front wall in spanning relation thereto, circulating pump means for receiving water from the lower portion of said drum and for forcing it into said distributing header, steam generating circuits made up of tubes that extend in parallel from said bottom header along the floor of said furnace space and of said gas pass space so as to line that floor and thence in spaced sinuous relation upwardly through said gas pass space to form convection heat absorbing surface therein and thence in parallel along the gas pass roof area so as to line that area exclusive of said first opening and further along the furnace space roof so as to line that roof and thence into said upper drum, other steam generating circuits made up of further tubes that line each of said left and right side walls and that are connected with said lower header to receive circulating water therefrom and with said upper drum to discharge steam and water mixture thereinto, and a transverse partition wall disposed between said forward furnace space and said rear gas pass space and serving to confine flow of combustion gases out of the furnace space to a second opening through that transverse partition which is opposite said first opening in the gas pass roof, said transverse partition wall being formed from parallel steam generating tubes which are sinuously bent back and forth in the plane of the transverse partition and which are connected with said water distributing header at their lower ends and with said steam and water drum at their upper ends, said transverse partition wall having said second opening therethrough located in the upper area of the partition wall and wherein there is provided between the left and right portions of said rear gas pass space a longitudinal partition wall which is disposed along one edge of said first opening in the gas pass roof and which extends downwardly from said roof to a point spaced above the gas pass floor, said longitudinal partition wall serving to separate the said convection heat absorbing surface on the longitudinal partition's left side from the said convection heat absorbing surface on the longitudinal partition's right side, said longitudinal partition wall being formed from parallel steam generating tubes which are sinuously bent back and forth in the plane of the longitudinal partition and which are connected with said water distributing header at their lower ends and with said steam and water drum at their upper ends.

3. In a steam generator of the package boiler type that is adapted to be assembled in the shop and to be shipped as an assembled unit, the combination of left and right side walls plus floor and roof walls and front and rear walls organized to define an enclosed space, said space including a forward furnace portion that extends rearwardly from said front wall and a rear gas pass portion that extends forwardly from said rear wall, burner means for bringing fuel into said furnace space along with air to support combustion of the fuel, means forming in the rear portion of said roof a first opening which communicates with one side of said gas pass space and through

which first opening combustion gases can discharge from that space, a steam and water drum disposed along the upper portion of said front wall in spanning relation thereto, a water distributing header disposed along the lower portion of said front wall in spanning relation thereto, circulating pump means for receiving water from the lower portion of said drum and for forcing it into said distributing header, steam generating circuits made up of tubes that extend in parallel from said bottom header along the floor of said furnace space and of said gas pass space so as to line that floor and thence in spaced sinuous relation upwardly through said gas pass space to form convection heat absorbing surface therein and thence in parallel along the gas pass roof area so as to line that area exclusive of said first opening and further along the furnace space roof so as to line that roof and thence into said upper drum, other steam generating circuits made up of further tubes that line each of said left and right side walls and that are connected with said lower header to receive circulating water therefrom and with said upper drum to discharge steam and water mixture thereinto, and a transverse partition wall disposed between said forward furnace space and said rear gas pass space and serving to confine flow of combustion gases out of the furnace space to a second opening through that transverse partition which is opposite said first opening in the gas pass roof, said transverse partition wall being formed from parallel steam generating tubes which are sinuously bent back and forth in the plane of the transverse partition and which are connected with said water distributing header at their lower ends and with said steam and water drum at their upper ends, said transverse

partition wall having said second opening therethrough located in the upper area of the partition wall and wherein there is provided between the left and right portions of said rear gas pass space a longitudinal partition wall which is disposed along one edge of said first opening in the gas pass roof and which extends downwardly from said roof to a point spaced above the gas pass floor, said longitudinal partition wall serving to separate the said convection heat absorbing surface on the longitudinal partition's left side from the said convection heat absorbing surface on the longitudinal partition's right side, said longitudinal partition wall being formed from parallel steam generating tubes which are sinuously bent back and forth in the plane of the longitudinal partition and which are connected with said water distributing header at their lower ends and with said steam and water drum at their upper ends, said steam generating tubes that form this longitudinal partition wall having within the confines of said wall internal diameters which are greater than the diameters of those portions of the same tubes that extend from the water distributing header to said longitudinal partition wall and that extend from said longitudinal partition wall to the steam and water drum.

References Cited in the file of this patent

UNITED STATES PATENTS

675,658	Hubbard	June 4, 1901
1,842,235	Barnes	Jan. 19, 1932
2,170,342	Bailey	Aug. 22, 1939
2,464,750	Nalven	Mar. 15, 1949
2,763,243	Marshall	Sept. 18, 1956