Aug. 16, 1966 R. D. WINSHIP 3,266,467

BOTTOM FIRED PACKAGE BOILER

Filed Nov. 25, 1964 4 Sheets-Sheet 1

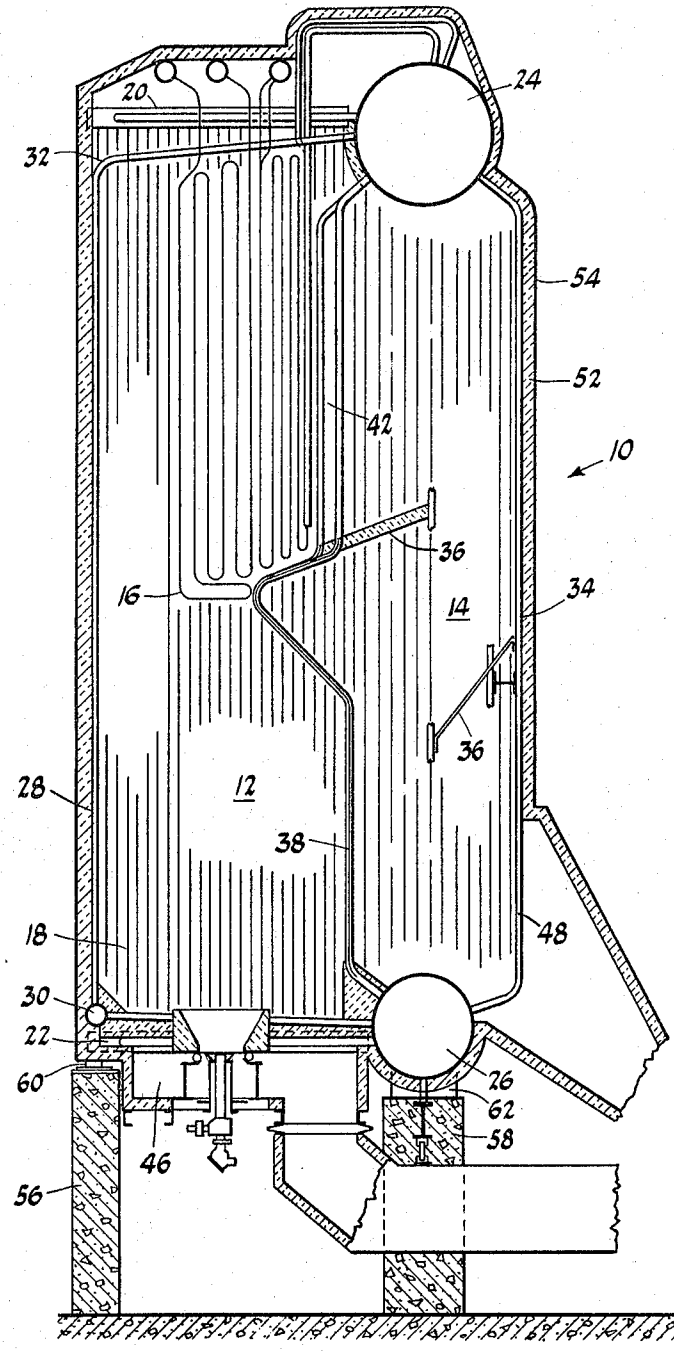



FIG. 1

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BOTTOM FIRED PACKAGE BOILER

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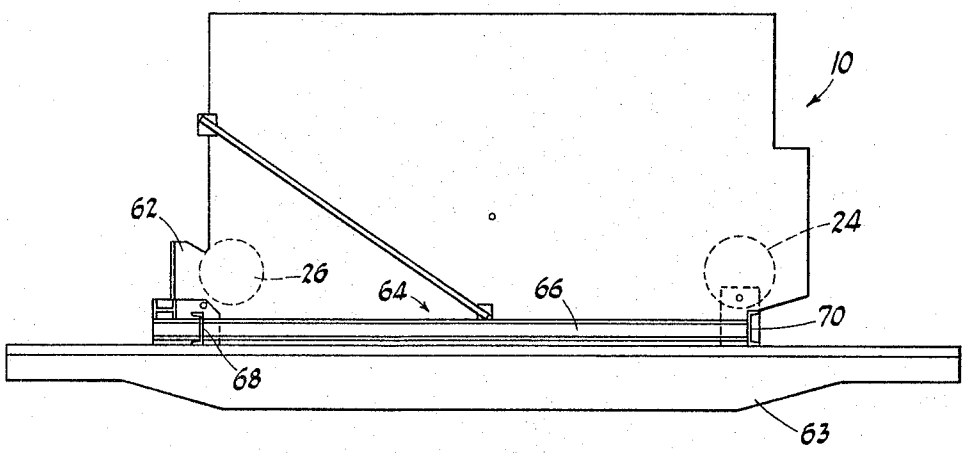



FIG. 2

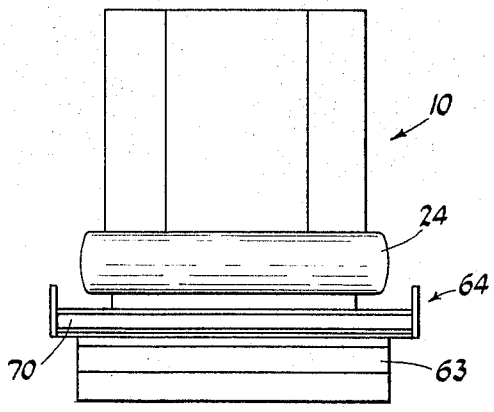



FIG. 3

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Aug. 16, 1966 R. D. WINSHIP 3,266,467

BOTTOM FIRED PACKAGE BOILER

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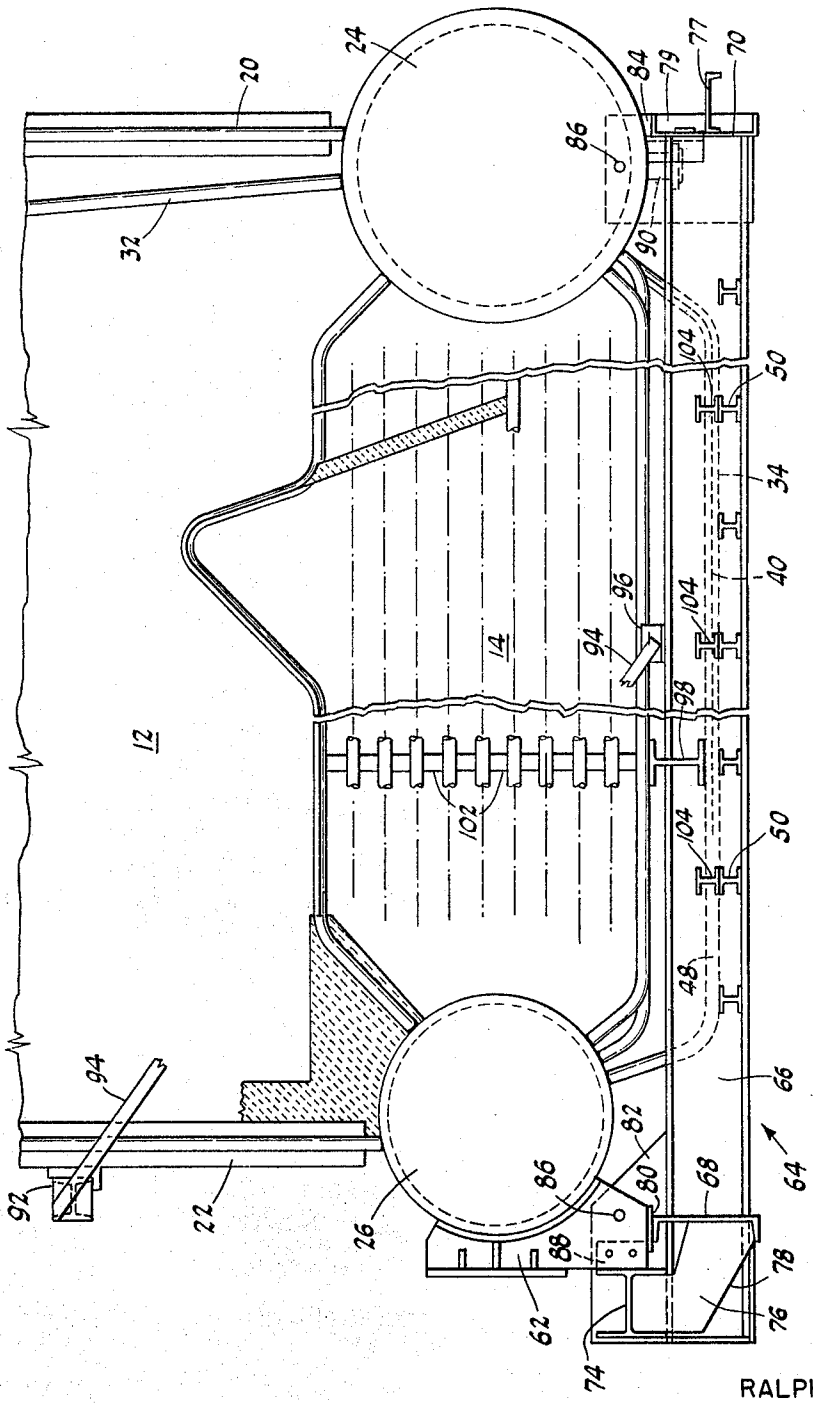



FIG. 4

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BOTTOM FIRED PACKAGE BOILER

Filed Nov. 25, 1964 4 Sheets-Sheet 4

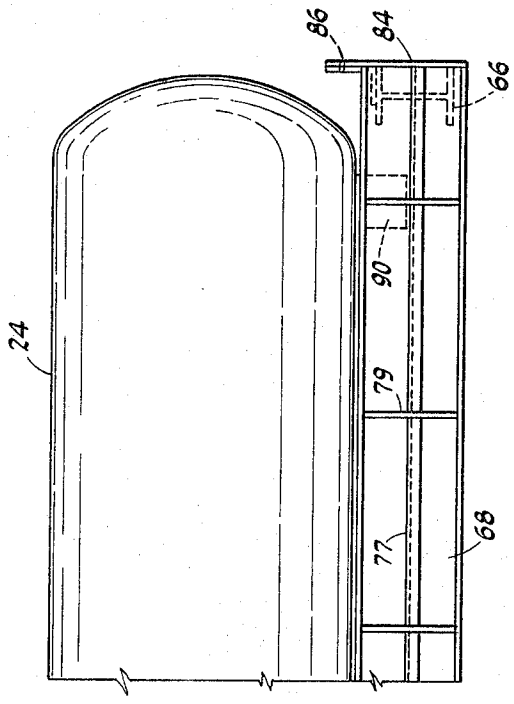



FIG. 6

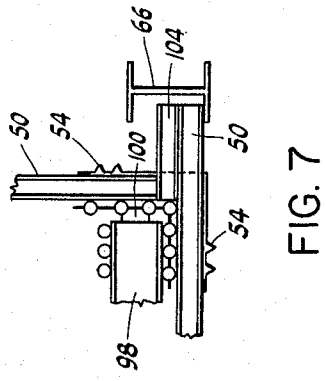



FIG. 7

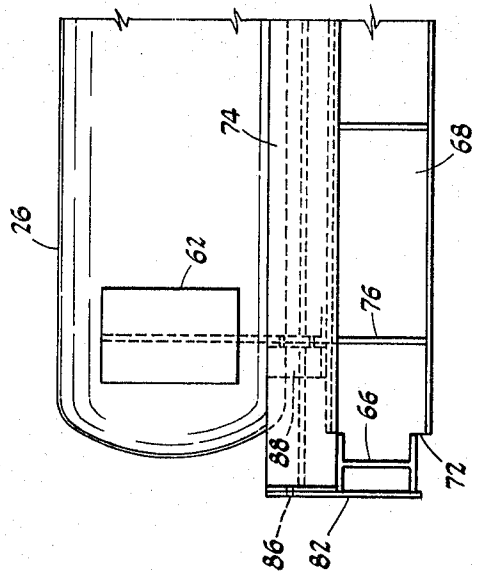



FIG. 5

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United States Patent Office 3,266,467
Patented August 16, 1966



3,266,467

# BOTTOM FIRED PACKAGE BOILER

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Filed Nov. 25, 1964, Ser. No. 413,835
4 Claims. (Cl. 122—510)

The present invention relates to steam generators, specifically that type of steam generator that is constructed in the shop and transported to the boiler site for erection, such steam generators being commonly known as "package boilers." More particularly, the invention relates to means for mounting a normally vertically arranged package boiler on the bed of a flatcar or other transport means in a horizontal attitude for shipment.

In the manufacture and design of package boilers limitations are placed on the dimensions of such units by railroad clearances. Heretofore, it has been the practice to ship package boilers in the vertical position while fixing the cross-sectional dimensions of the unit by the shipping clearances and effecting increases in furnace size and boiler heating surface by increasing the length of the units while holding their cross-section constant. This practice gives rise to several inherent disadvantages. Under present conditions an increase in package boiler size must be accompanied by an increase in the amount of floor space required to accommodate the unit. Therefore, in those locations where floor space is at a premium, the installation of a package boiler of increased capacity would be extremely difficult, if not impossible. Moreover, the need to effect an increase in capacity by increasing furnace length while maintaining the cross-sectional dimensions constant gives rise to the disadvantage of increased cost per square foot of heating surface. Such disadvantage is realized because of the fact that the amount of heating surface available per tube is less for a unit of smaller vertical dimension. Therefore, an increase in heating surface necessitates added fabrication and fitting expenditures for the unit since a greater number of tubes is required.

The present invention contemplates means for offsetting the aforesaid undesirable characteristics in package boilers in addition to accomplishing other manifest advantages. The invention permits package boiler units to be mounted in a horizontal attitude during shipment in a manner that maintains boiler dimensions within tolerable railroad clearances. This permits the design of package boilers having capacities greater than heretofore-designed units. The unit is transported to the boiler site in the horizontal position and then is rotated into its erected vertical position by means of lifting cranes.

The instant inventive concept involves provision of a cradle beam structure capable of supporting a package boiler in a horizontal position during shipment in a manner that prevents the undue stressing of the boiler's pressure parts. Because of the enablement of the shipment of package boilers in such a way many of the disadvantages heretofore characteristic of package boilers are eliminated. For example, the use of steam drums having greater diameters and therefore units having much greater steaming capacities are permitted. Also, increases in boiler capacities can be effected without an increase in the amount of floor space required for the units. Still further, heating surface increases in boilers in order to obtain greater steam capacity can be effected without increasing the number of tubes employed, thereby reducing the cost of the units per pound of steam generated.

Another manifest advantage of the instant invention is derived from the fact that package boilers can now be constructed with a gas flow passage that establishes communication between the boiler bank and the furnace chamber throughout the entire width of the unit. Due



to such a gas flow passage the temperature of the gases that impinge upon the steam drum are substantially the same throughout the length of the drum thereby eliminating the thermal gradient that existed along the axis of steam drums employed in the package boilers of the prior art wherein, due to shipment restrictions, the gas flow pass was caused to communicate with the furnace chamber at one side thereof whereby the flow of gases through the boiler bank occurred along the axis of the drum. This flow of gases along the axis of the drum with its attendant change in gas temperature resulted in a greater amount of steam generation at one end of the drum than at the other thus giving rise to a non-uniform water level in the drum. In the present unit the gas flow being transverse to the drum axis effects elimination of the attendant disadvantage of a non-uniform water level within the drum thereby facilitating the control of drum water level and also removing the restriction placed upon the installation of drum internals therewithin.

It is therefore an object of the instant invention to provide means for mounting a package boiler for shipment in a manner that permits the design of units having increased vertical dimensions yet that enables units having such dimensions to be capable of shipment in light of established clearance restrictions.

Another object of the invention is to provide means that effect the mounting of a package boiler unit in a horizontal position during shipment in a manner that prevents the undue stressing of the boiler's pressure parts.

Still another object is to provide means for mounting a package boiler in a horizontal position during shipment and for erecting such unit at the boiler site by rotating it from its horizontal attitude to a vertical, installed attitude in a manner that prevents undue stressing of the pressure parts and connections.

Other objects and advantages will appear from the following description of one embodiment of the invention, and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

The invention is described with reference to the accompanying drawings wherein:

FIGURE 1 is a sectional side elevation of an installed package boiler of the type contemplated by the present invention;

FIGURES 2 and 3 are side and end elevations of a package boiler mounted on a flatcar bed in accordance with the present invention;

FIGURE 4 is a partial sectional side elevation of a package boiler horizontally mounted upon the cradle beam assembly of the present invention;

FIGURES 5 and 6 are partial end views of the cradle beam assembly of the present invention; and

FIGURE 7 is a partial section taken along line 7—7 of FIGURE 4.

Referring now to the drawings, FIGURE 1 discloses a package boiler **10** of the type contemplated by the present invention in its installed or erected position. The boiler **10** is of the two-drum type and comprises a furnace section **12**, a boiler bank or convection heating section **14** and a superheater **16**. The unit is bounded by rectangularly disposed walls including side walls **18** formed of tubes extending between upper and lower headers **20** and **22**, each of which communicates with the upper and lower drum, respectively, by means of appropriate connections. The front wall **28** is formed of tubes emanating from a transverse lower header **30** and extending vertically into tubes forming the roof **32**, the latter being directly connected to the upper drum **24**. The rear wall of the unit, indicated as **34**, comprises the rearwardmost row of boiler bank tubes which are connected at each end to the upper drum **24** and lower drum **26**. As shown, these tubes are substantially C-shaped and project rear-

wardly beyond the rearwardmost surface of the two drums. The tubes forming the walls of the boiler can be either plain, tangent-spaced tubes, finned tubes, or of the common welded wall construction. The remainder of the boiler bank section **14** comprises parallel rows of vertically extending subtantially C-shaped tubes connecting the upper drum **24** with the lower drum **26**. During operation of the boiler some of these tubes receive a greater amount of heat from the combustion gases generated in the furnace and therefore serve as risers conducting steam and water mixture to the upper drum **24**. The others, which receive less heat, serve as downcomers conducting separated fluid and feedwater to the lower drum **26**. Refractory baffles **36**, two of which are shown in the disclosed arrangment, are positioned at spaced levels within the boiler bank being connected to selected tubes at those levels and so disposed to direct gases flowing through the boiler bank along a substantially sinuous path to effect more efficient heat transfer between the gases and the fluid flowing through the tubes.

One row of steam generating tubes forms a tubular partition **38** separating the furnace section **12** from the boiler bank **14**. These tubes extend between the upper and lower drums **24** and **26** and, as shown in FIGURE 1, present a gas impervious structure in the lower portion thereof by means of welded, gas impervious fins **40** which unite adjacent tubes and which serve to connect the endmost tubes of the partition to the side walls **18**. The tubes in the upper portion of the partition **38** are not finned, but are spacedly offset as shown to provide openings **42** permitting gases generated in the furnace **12** to flow to the boiler bank **14**. A superheater **16** formed of sinuously-shaped tubes may be positioned adjacent the openings **42**.

The disclosed package boiler has burner means **44** surrounded by a windbox **46** and located in the furnace floor. The burners **44** are so disposed as to effect firing in a vertical direction whereby the combustion gases are caused to flow upwardly through the furnace section **12**, thence through the superheater **16** and into the the convection section or boiler bank **14** where they are directed downwardly and exit the unit through an opening **48** provided at the bottom of the rear wall. From here the gases can flow to an air heater or other ancillary equipment (not shown) before passing out a stack. Completing the boiler structure are spaced buckstays **50** attached to the walls **18**, **28**, and **34**. They surround the unit structure being welded to the wall-forming tubes and serve to strengthen or rigidify these walls for the purpose of enabling the walls to withstand minor furnace explosions or the like. Insulating material **52** is attached to the boiler walls by any suitable means and covers the exterior of the unit. Covering the insulating material is an outer casing **54** formed of thin sheet metal.

When erected, the described package boiler **10** sits on footings **56** and **58** which can be formed of concrete or other like material and which support the unit vertically at four corners of its base. As shown, saddles **60** support the ends of the lower side wall headers **22** upon the front footings **56**. The rear drum saddles **62** which are attached to the lower drum **26** are positioned upon the rear footings **58**. In this manner the unit is bottom supported and adapted for vertical thermal expansion.

The operation of the disclosed unit is substantially conventional. Feedwater is admitted to the upper drum **24** where it mixes with water separated from the steam-water mixture by processing equipment (not shown) in the upper drum. The water circulates downwardly through the tubes serving as downcomers in the boiler bank to the lower drum **26**. From here it is supplied to the tubes forming the walls of the furnace section **12** and those which are the risers within the boiler bank **14**. Fuel is fed to the burners **44** which generate combustion gases within the furnace **12**. These gases flow in an upwardly direction through the furnace section and thence through



the superheater **16** and into the boiler bank section **14**. By means of the heat transfer relation between the gases and the fluid flowing through the tubes a steam and water mixture is created and natural circulation of the fluid is induced.

As stated above, it has always been the practice to transport package boilers in an erect or upright position upon the bed of a flatcar or other transport means in shipping them from the manufacturing site to the boiler site. Because of limitations imposed by railroad clearances the height of the units transported cannot exceed approximately 16 feet. This requires, therefore, that the vertical dimension of the boiler be maintained at a value somewhat less than 16 feet, and the cross-sectional dimensions of the units be maintained substantially constant. Because of this practice, the added heating surface necessary to obtain greater steam generating capacity must be added to the longitudinal dimension of the boiler, thereby requiring more floor space to accommodate these units of greater capacity. Moreover, the maximum capacity of such units is limited by the amount of gas weight that can be accommodated through the gas passing sections of the unit without the establishment of excessively high gas velocity. Because the cross-sectional dimensions of package boilers are fixed, the dimensions of the boiler bank are also fixed, and the amount of heating surface can be increased only by increasing the length of the gas pass containing this heating surface. If an excess of tubes is positioned within the gas pass the gas velocity would become too great for effective heat transfer, thereby lessening the efficiency of the units. The steam capacities of these package boilers therefore is limited to that capacity which can be generated by means of the limited amount of heating surface capable of being positioned within the gas pass or boiler bank.

In accordance with the present invention, means are provided that permit a package boiler to be horizontally mounted upon the bed of a transport means such as a flatcar or the like during transport to the boiler site. By transporting the unit in this manner many of the above mentioned disadvantages heretofore characteristic of package boilers are overcome and several other manifest advantages are derived.

As shown in FIGURES 2 and 3 the fully constructed package boiler **10** is laid horizontally with its rear wall **34** lowermost upon the bed **63** of a flatcar. Supporting the boiler is a cradle beam assembly **64** that comprises a number of rectangularly disposed structural members arranged to receive the gravitational loading or weight of the boiler in a manner that prevents overstressing of the boiler's component pressure parts. The cradle beam assembly **64** comprises a pair of oppositely spaced I-beams, designated the longitudinal members **66**, that extend along the boiler rear wall **34** between the lower drum **26** on the left and the upper drum **24** on the right. A pair of channels, designated the lateral members **68** and **70**, are positioned substantially beneath the lower and upper drums respectively and extend beyond the boiler side walls connecting to the longitudinal members **66**. The ends of the left lateral member **68** are shaped by removal of a portion of the flanges and web thereof as indicated at **72** such that they are snugly received within the flanges of the longitudinal members **66** at a position somewhat inwardly of the ends thereof. A weld is applied along the flanges and web of the longitudinal members **66** to complete the connection. Unlike the left lateral member **68** the right lateral member **70** is arranged in web-abutting relation with the right-hand ends of the longitudinal members **66**. A weld is applied to rigidly connect the members. A lateral stiffening beam **74** extends between the left ends of the members **66** and is attached thereto by means of welds connecting the flanges of the members. This member is intended to provide additional support at the lower end of the boiler when the unit is being rotated through its erect position to be described.

hereinafter. Additional stiffening at this end is provided by a plurality of gussets **76** which extend between and are connected to the webs and flanges of the lateral stiffening beam **74** and the left lateral member **68**. As shown the lower edge **78** of the gussets **76** is diagonally cut so as to facilitate rotation of the unit into its vertical position. A lateral stiffening channel **77** is welded to and extends along the length of channel **70** to stiffen the structure at this end. Gussets **79** further stiffen the structure in this area. Bearing pads **80** are attached to the upper flange of left lateral member **68** and positioned to receive the bearing surface of the drum saddles **62** that mount the lower drum **26**. Lifting plates **82** and **84** are weldedly united to the ends of longitudinal members **66** at the four corners of the cradle beam assembly. The plates **82** and **84** are apertured at **86** to receive the lifting hooks of a crane (not shown) for the purpose of first, lifting the package boiler and cradle beam assembly onto the flatcar bed **63** and secondly, in the case of the apertures in plates **84**, for rotating the unit into erected position at the boiler site. Apertured angle members **88** are attached to the inside flange of the lateral stiffening beam **74** and serve to attach the drum saddles **62** to the cradle beam assembly by means of a breakable connection such as threaded bolts or the like. The connection between the boiler and cradle beam assembly at the other end is effected by means of angle members **90** or the like having one leg welded to the drum at spaced points and the other leg apertured in alignment with similar apertures in the right lateral member **70**. Bolts received within the apertures serve to attach the angle member to the lateral member **70**.

A header tie arrangement may be employed to support the hollowed side wall headers **22** during erection of the boiler. It consists of a structural beam **92** attached to the lower side wall headers **22** and arranged to receive one end of tie rods **94** and bosses **96** attached to the upper flange of longitudinal members **66** at substantially their mid-point. The bosses **96** are recessed to receive the ends of tie rods **94**.

Means are provided within the boiler itself for supporting the pressure parts and for transferring the loading of these pressure parts to the cradle beam assembly. These means include a beam **98** which extends substantially the full width of the boiler and is installed between the tubes forming the boiler rear wall **34** and the next adjacent row of boiler bank tubes. The ends of this beam are attached to the boiler side walls by means of plates **100** that are scalloped so as to fit between adjacent side wall tubes. The plates **100** are welded to the beam **98** and to the side wall tubes and remain a permanent part of the boiler. Spacer members **102** extend the width of the boiler and are positioned between adjacent rows of boiler bank tubes in alignment with the support beam **98**. The purpose of these spacers is to prevent vibration of the boiler bank tubes while the unit is lying in its horizontal position during transit in order to prevent vibration of the tubes which might tend to damage or destroy the refractory baffles **36**. These spacers **102** are conveniently formed of wood which can be destroyed when the boiler is first operated by the combustion gases which flow through the boiler bank and effect ignition of the spacers.

As shown in FIGURE 4 a loading of the rear wall **34** is transferred to the cradle beam assembly by means of the rear wall buckstays **50** which extend beyond the boiler side walls **18** so as to engage the lower flange of the longitudinal members **66**. Due to the fact that those buckstays adjacent the boiler bank support beam **98** will undergo a greater amount of compressive stress, it may be necessary to strengthen the buckstays and such is conveniently effected by attaching a short length of an I-beam **104** to the buckstay upper flange as by means of welding.

The operation of the arrangement is as follows. The cradle beam assembly is mounted to the constructed package boiler which normally stands in a vertical or erected position. The mounting is effected by connections between the angles **88** mounted to the lateral stiffening beam **74** and the drum saddles **62** at the lower end of the boiler and by similar connections between the upper angle member drum **90** and the apertures in the right lateral member **70**. After these connections have been made, crane hooks are attached to the apertures in the right lifting plates **84** and the unit is rotated to its horizontal position. Another set of crane hooks engages the apertures in the left lifting plates **82** and the entire assembly is lifted onto the bed **63** of the flatcar to be used to transport the boiler.

With the boiler mounted on the flatcar in this manner its weight, rather than being supported by the tubes forming the rear wall **34**, is transferred to the cradle beam assembly, first, because of the rigid connection between the cradle beam and the boiler drums **24** and **26** and secondly, due to the transfer of loading from the rear wall to the longitudinal members **66** effected by means of the rear wall buckstays **50**. Moreover, because the spacers **102** prevent vibration of the boiler bank tubes during transit the refractory baffles **36** mounted in the boiler bank **14** are prevented from being damaged.

When it is desired to erect the boiler at its site, lifting hooks again engage the lifting plates **82** and **84** and the threaded connection existing between the upper drum angles **88** and the right-hand lateral member **68** is broken, but the bolts are permitted to remain in the apertures. This permits relative motion along a line parallel to the surface of the rear wall between the upper drum **24** and the cradle beam assembly **64**. Thereafter, the crane engaging the right lifting plates **84** raises that end causing the boiler to pivot about a point adjacent the lower drum **26**. When this occurs the loading of the boiler will tend to shift from the longitudinal members and other components of the cradle beam assembly **64** to the drum saddles **62** and side wall headers **22** which are mounted upon footings **56** and **58**. Because the connection between the upper drum and the cradle beam assembly is now loose, the boiler pressure parts are permitted to take a natural set thereby alleviating any undue tensile stressing of the pressure parts or of their connections.

While the instant invention has been disclosed with reference to a particular embodiment thereof, it is to be appreciated that the invention is not to be taken as limited to all of the specific details thereof as modifications and variations thereof can be made without departing from the spirit or scope of the invention.

What is claimed is:

**1.** In combination with a normally vertically arranged tubulous package boiler assembly having opposed front, rear and side walls and a roof defining an enclosed furnace chamber, a boiler bank opening into said furnace chamber including substantially parallelly disposed upper and lower drums located at the rear of said boiler assembly and disposed laterally of said side walls, a bank of parallelly disposed tubes arranged in aligned rows connecting said drums, the rearwardmost row thereof defining the rear wall of the boiler assembly and refractory baffle means extending the width of said boiler bank and intersecting a plurality of said boiler bank tubes, the improvement which comprises means for mounting said package boiler assembly in a horizontal attitude upon transport means during shipment thereof including a cradle beam assembly adapted to rest on the bed of said transport means comprising rectangularly arranged support beams connected at their corners and of sufficient height that, when connected to said boiler assembly, will maintain the rear wall thereof above said bed; detachable means connecting said cradle beam assembly to said drums adjacent to the opposed ends thereof, the connection thereof being capable of transferring the vertical loading of said drums to said cradle beam assembly; vertically aligned spacer members extending substantially the width of said boiler bank interpositioned between adjacent rows

of tubes and means for transferring the vertical loading of said spacer members to said cradle beam assembly.

2. In combination with a normally vertically arranged tubulous package boiler assembly having opposed front, rear and side walls and a roof defining an enclosed furnace chamber, a boiler bank opening into said furnace chamber including substantially parallelly disposed upper and lower drums located at the rear of said boiler assembly and disposed laterally of said side walls, a bank of parallelly disposed tubes arranged in aligned rows connecting said drums, the rearwardmost row thereof defining the rear wall of the boiler assembly and refractory baffle means extending the width of said boiler bank and intersecting a plurality of said boiler bank tubes, the improvement which comprises means for mounting said package boiler assembly in a horizontal attitude upon transport means during shipment thereof including a cradle beam assembly adapted to rest on the bed of said transport means comprising rectangularly arranged support beams connected at their corners and of sufficient height that, when connected to said boiler assembly, will maintain the rear wall thereof above said bed; detachable means connecting said cradle beam assembly to said drums adjacent to the opposed ends thereof, the connection thereof being capable of transferring the vertical loading of said drums to said cradle beam assembly; the connection between the upper drum and said cradle beam assembly being capable of effecting relative sliding movement therebetween along a line parallel to said boiler assembly rear wall; vertically aligned spacer members extending substantially the width of said boiler bank interpositioned between adjacent rows of tubes and means for transferring the vertical loading of said spacer members to said cradle beam assembly.

3. In combination with a normally vertically arranged tubulous package boiler assembly having opposed front, rear and side walls and a roof defining an enclosed furnace chamber, a boiler bank opening into said furnace chamber including substantially parallelly disposed upper and lower drums located at the rear of said boiler assembly and disposed laterally of said side walls, a bank of parallelly disposed tubes arranged in aligned rows connecting said drums, the rearwardmost row thereof defining the rear wall of the boiler assembly, and refractory baffle means extending the width of said boiler bank and intersecting a plurality of said boiler bank tubes, buckstay means surrounding and being weldedly attached to the walls of said boiler assembly, the improvement which comprises means for mounting said package boiler assembly in a horizontal attitude upon transport means during shipment thereof including a cradle beam assembly adapted to rest on the bed of said transport means comprising rectangularly arranged support beams connected at their corners and of sufficient height that, when connected to said boiler assembly, will maintain the rear wall thereof above said bed, detachable means connecting said cradle beam assembly to said drums adjacent the opposed ends thereof, the connection thereof being capable of transferring the vertical loading of said drums to said cradle beam assembly, vertically aligned spacer members extending substantially the width of said boiler bank interpositioned between adjacent rows of tubes, and means for transferring the vertical loading of said spacer members to said cradle beam assembly including lateral extensions of said buckstay beams attached to the boiler assembly rear wall with opposed ends thereof in abutting engagement with said cradle beam assembly.

4. In combination with a normally vertically arranged tubulous package boiler assembly having opposed front, rear and side walls and a roof defining an enclosed furnace chamber, a boiler bank opening into said furnace chamber including substantially parallelly disposed upper and lower drums located at the rear of said boiler assembly and disposed laterally of said side walls, a bank of parallelly disposed tubes arranged in aligned rows connecting said drums, the rearwardmost row thereof defining the rear wall of the boiler assembly, and refractory baffle means extending the width of said boiler bank and intersecting a plurality of said boiler bank tubes, buckstay means surrounding and being weldedly attached to the walls of said boiler assembly, the improvement which comprises means for mounting said package boiler assembly in a horizontal attitude upon transport means during shipment thereof including a cradle beam assembly adapted to rest on the bed of said transport means comprising rectangularly arranged support beams connected at their corners and of sufficient height that, when connected to said boiler assembly, will maintain the rear wall thereof above said bed, detachable means connecting said cradle beam assembly to said drums adjacent the opposed ends thereof, the connection thereof being capable of transferring the vertical loading of said drums to said cradle beam assembly, and the connection between the upper drum and said cradle beam assembly being capable of effecting relative sliding movement along a line parallel to said boiler assembly rear wall, vertically aligned spacer members extending substantially the width of said boiler bank interpositioned between adjacent rows of tubes, and means for transferring the vertical loading of said spacer members to said cradle beam assembly including lateral extensions of said buckstay beams attached to the boiler assembly rear wall with opposed ends thereof in abutting engagement with said cradle beam assembly.

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KENNETH W. SPRAGUE, *Primary Examiner.*