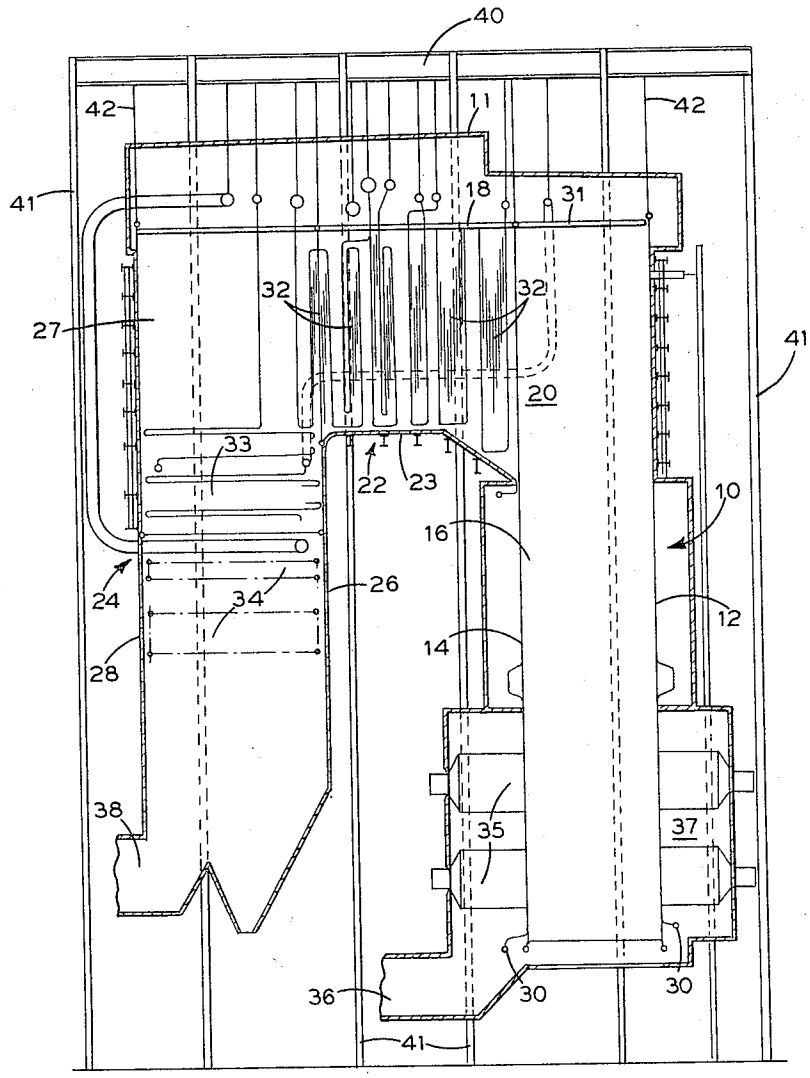
Jan. 31, 1967 H. A. BOE ETAL 3,301,225

VAPOR GENERATOR WALL BUCKSTAY ARRANGEMENT

Filed March 29, 1965 3 Sheets-Sheet 1

FIG. 1



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VAPOR GENERATOR WALL BUCKSTAY ARRANGEMENT

Filed March 29, 1965 3 Sheets-Sheet 2

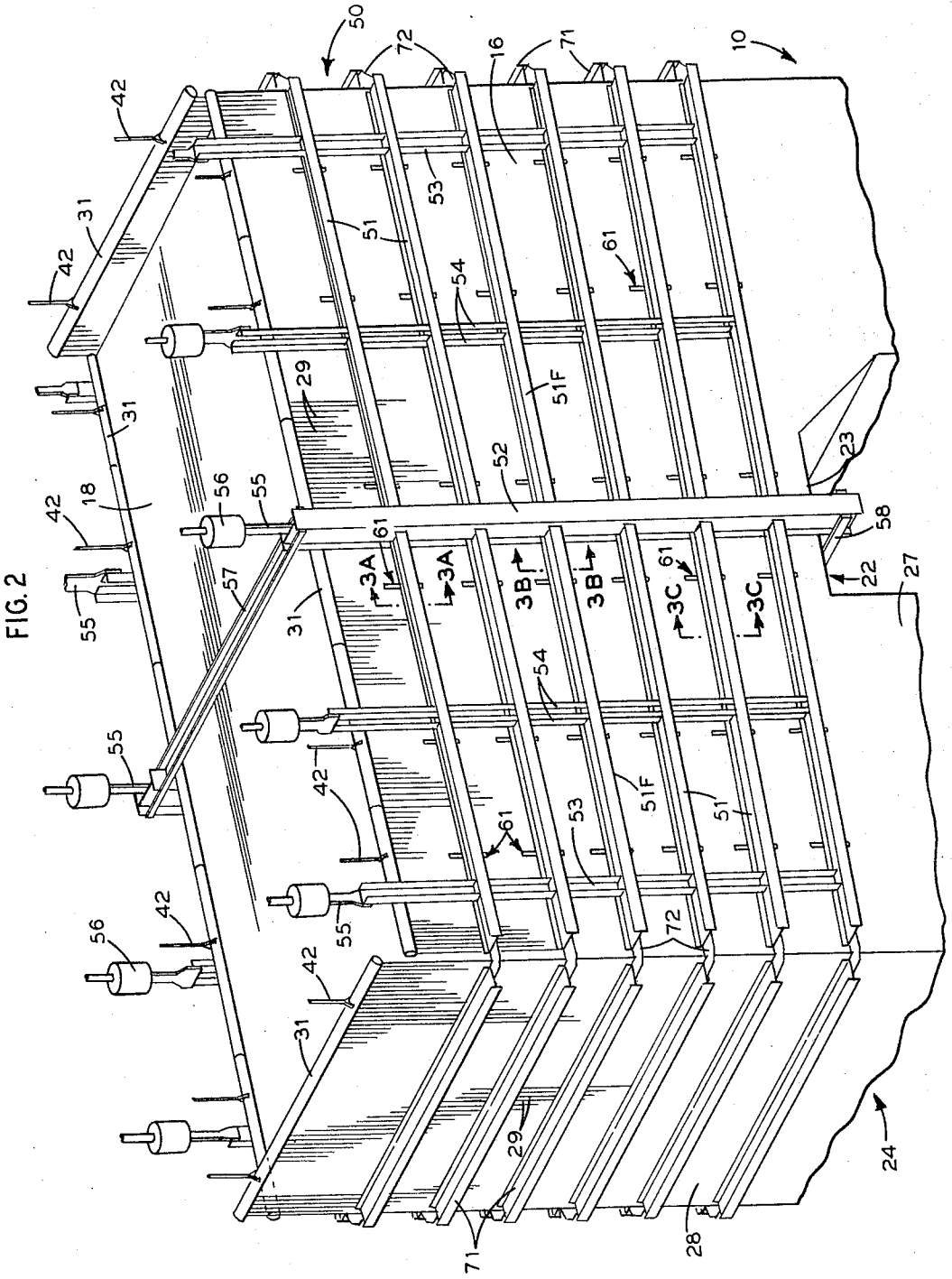


FIG. 2

VAPOR GENERATOR WALL BUCKSTAY ARRANGEMENT

Filed March 29, 1965 3 Sheets-Sheet 3

FIG. 3A

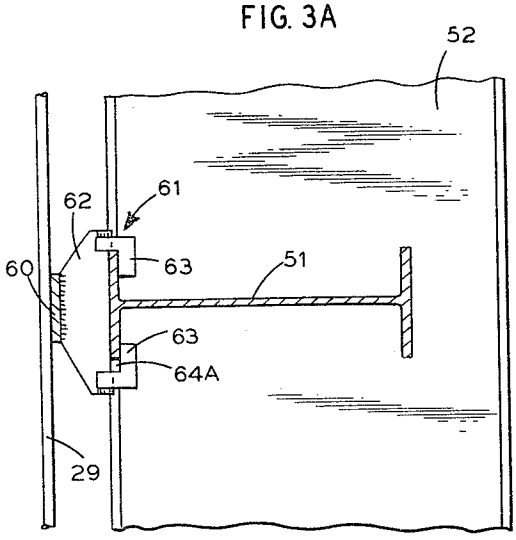


FIG. 4

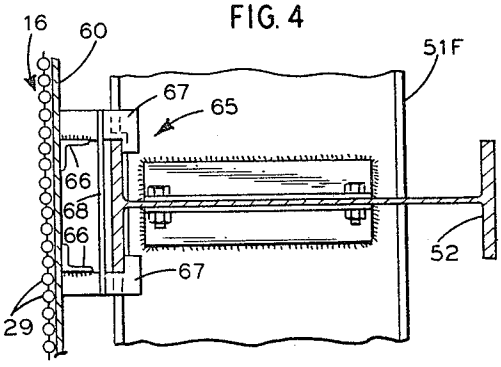


FIG. 3B

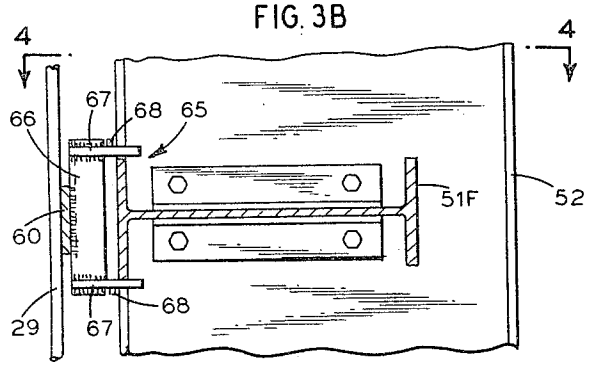
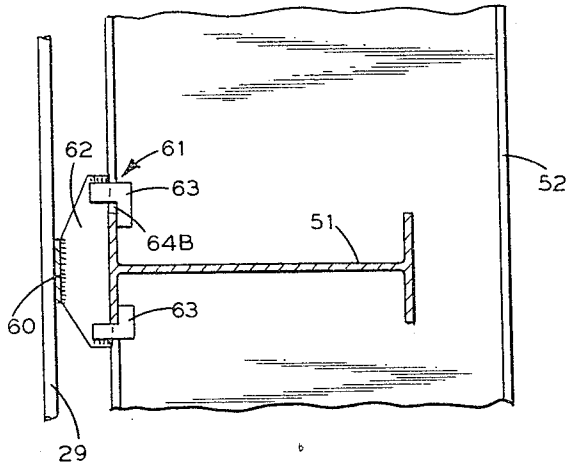


FIG. 3C



United States Patent Office 3,301,225 Patented Jan. 31, 1967

3,301,225

VAPOR GENERATOR WALL BUCKSTAY ARRANGEMENT

Harvey A. Boe, Wadsworth, and Donald J. Kassner, Massillon, Ohio, assignors to The Babcock & Wilcox Company, New York, N.Y., a corporation of New Jersey

Filed Mar. 29, 1965, Ser. No. 443,201
14 Claims. (Cl. 122—510)

This invention relates generally to a wall construction of a vapor generator, and more particularly to a buckstay arrangement for reinforcing a fluid-cooled tubular wall defining in part a chamber in which hot combustion gases are confined.

It has been customary in the erection of vapor generators to provide externally mounted buckstay assemblies for the purpose of affording lateral support to the walls of the vapor generator to hold the wall in alignment and as reinforcement against the effect of draft and/or pressure of the flue gas stream within the confines of the vapor generator. Where the vapor generator walls are formed of upright fluid-cooled tubes, the buckstay assemblies normally extend horizontally around the outside of the unit at spaced elevations along its height. The wall tubes are in heat transfer relationship with the high temperature combustion gases on the inside of the vapor generator and are therefore subject to a substantial amount of thermal linear expansion as the unit is operated from its cold, non-operative condition to its hot, full-load operating condition. The buckstay members, being located externally of the unit and out of communication with the hot gases, are conversely not subject to any substantial amount of linear thermal expansion. Thus, provisions must be made for relative movement between the walls and buckstays due to the relative amounts of thermal expansion. Heretofore, it has been the usual practice to accommodate the vertical relative movement by hanging the buckstays on the furnace walls so that the buckstays "float" with the vertical expansion movements of the walls. Horizontal expansion of the walls relative to the buckstays is normally accommodated by providing pin and slot connections between the walls and buckstays. A more recent innovation for accommodating relative horizontal expansion movements between walls and buckstays is shown in U.S. Patent No. 3,007,455, issued November 7, 1961, in the name of C. Lieb et al., wherein pivotal linkage members interconnect the ends of the buckstays with the furnace walls. It should be noted, however, that even in this recent buckstay arrangement the weight of the buckstay members is carried by the walls, i.e., the buckstays are "hung" on the walls.

In recent years, economy has dictated a continual increase in the steaming capacity and size of vapor generating units. This trend, coupled with the operation of these units at higher positive fire-side pressures, dictates that the cross-sectional area of the buckstays required to afford adequate support to the walls of these large vapor generators be increased to almost impractical dimensions. As an example of this, in a recent design study of a large central station vapor generator of the usual top-supported design, the furnace was to be operated at a pressure of 30 inches of water, and a single wall span was almost 100 feet wide. Calculations indicated that the buckstay members of the design shown, for example, in the above-mentioned U.S. patent would have to be at least 60 inches in depth having a wall span of that magnitude. The use of such large buckstay members would result in more costly fabrication of support steel since the vertical support column centers normally used for the unit would have to be increased in order to accommodate the increased size of such wide buckstays. Since the tubes forming the vapor generator walls are preferably of relatively small diameter, i.e., about 1 inch O.D., the added weight of such large buckstays accentuates the problems of allowable loading limits which may be satisfactorily accommodated by the wall tubes.

It is therefore an object of the present invention to provide an improved buckstay arrangement for a large wall span of a high capacity vapor generator, the buckstay system being such that the size of the buckstay structural members is less than would be required by present design standards to afford adequate lateral wall support. It is a further object of the present invention to relieve the vapor generator walls of the burden of supporting the weight of the entire buckstay system.

To accomplish these and other objects which will become apparent, in accordance with the present invention there is provided a fluid heating unit comprising walls defining an upright furnace chamber wherein fuel is consumed to produce hot combustion gases, and walls defining an upright convection gas pass adjacent said furnace chamber. The upper portions of the furnace chamber and convection gas pass are interconnected for the flow of combustion gases from the former to the latter by means including a pair of spaced upright parallel side walls common to the furnace chamber and convection pass. A rigid support structure extends above the furnace chamber and convection gas pass, and support rods interconnect the support structure and the side walls for the pendent support thereof. The buckstay system for providing lateral support and reinforcement to the side walls includes a buckstay grid adjacent each of the side walls. Each grid includes a plurality of vertically spaced horizontal structural members, and at least one vertical structural member. The horizontal structural members are attached to their adjacent side wall so as to permit relative movement between the side wall and the horizontal structural members in a horizontal direction parallel to the plane of the side wall. Means are provided for rigidly attaching only one of the horizontal structural members to both the vertical structural member and the side wall, thereby fixing the relative vertical positions of the side wall with respect to the vertical structural member and the one horizontal structural member at one elevation. The vertical structural member is pendently supported from the top support structure, and is engaged with the remainder of the horizontal structural member. Rigid side-to-side tie members extend transversely between the side walls outside of said heating chamber and interconnect the vertical structural members disposed adjacent opposite side walls to restrain said vertical structural members from movement away from their respective side walls.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a partially diagrammatic sectional side view of a fluid heating unit or vapor generator on which the inventive buckstay arrangement may be used;

FIG. 2 is a partially diagrammatic isometric view of the upper portion of the vapor generator of FIG. 1 showing the general arrangement of the buckstay system;

FIG. 3A is a partial sectional view taken along line 3A—3A of FIG. 2;

FIG. 3B is a partial sectional view taken along line 3B—3B of FIG. 2;

FIG. 3C is a partial sectional view taken along line 3C—3C of FIG. 2; and

FIG. 4 is a sectional vew taken along line 4—4 of FIG. 3B.

Referring to FIGS. 1 and 2, there is illustrated a vapor generating unit, the main portions of which include an upright furnace chamber **10** of substantially rectangular horizontal cross-section defined by a front end wall **12**, a rear wall **14**, side walls **16** and a roof **18** and having a gas outlet **20** at its upper end opening to a horizontally extending gas pass **22** of rectangular vertical cross-section formed by a floor **23** and extensions of the furnace roof **18** and side walls **16**. The gas pass **22** communicates at its rear end with the upper end of an upright convection gas pass **24** of rectangular horizontal cross-section formed by a front wall **26**, a rear end wall **28**, side walls **27** in planes common with the side walls **16** of the furnace chamber **10**, and a further extension of the roof **18**.

The walls of the furnace chamber **10**, horizontal gas pass **22** and convection gas pass **24** are preferably formed with a plurality of upright contiguous interconnected tubes **29** through which is passed the fluid to be heated. Fluid is supplied to these tubes via supply headers **30** to which the tubes are connected and which are generally disposed at the lower ends of their respective walls. The tubes **29** are similarly connected at their discharge ends to collection headers **31** disposed generally at the upper ends of the walls. The initial heating of the fluid is accomplished in the economizer tube banks **34** disposed in the lower portion of the convection gas pass **24**, and the final stages of fluid heating are accomplished in the pendent type vapor heaters **32** disposed in the horizontal gas pass and in the horizontal tube banks **33** disposed in the convection gas pass **24**.

Heating gases are supplied to the lower portion of the furnace chamber **10** by burning fuel in the cyclone type burners **35**, to which combustion air is supplied via duct **36** and windbox **37**. Combustion of the fuel is completed in the furnace chamber **10** which is operated at a positive pressure of about 25 inches of water, and the hot gaseous combustion products pass upwardly through the furnace chamber **10** and then laterally through the horizontal gas pass **22** and then downwardly through the convection gas pass **24** to the discharge duct **38**. The gaseous combustion products, the temperature of which has been decreased materially at this point, and then normally passed to an air heater (not shown) wherein ambient temperature combustion air is preheated by indirect heat exchange with the gaseous combustion products prior to their being exhausted to the atmosphere.

The entire vapor generating unit is pendently supported at its upper end from the top support structure **40** which is supported by upright columns **41** affixed to suitable foundations at ground level. The vapor generator walls are connected to the top support structure **40** by rigid support rods **42** preferably connected to the collection headers **31** disposed at the upper ends of the walls. It should be recognized that, with the vapor generating unit being pendently supported as described above, the linear thermal expansion of the unit between its cold (non-operating) condition and its hot (operating) condition will be in a downward direction. It should further be noted that the vertical thermal expansion movement of the lowermost portion of the unit will be greater than the vertical thermal expansion movement of any portion of the unit above its lowermost portion. As an example of the amount of linear thermal expansion involved in a large modern vapor generator, it is common that the lowermost portion of a unit will move downwardly by as much as 8 inches as the temperature of the vapor generator is increased from its non-operating condition to its normal equilibrium condition of operation.

For the purposes of affording lateral support to and maintaining the alignment of the walls of the vapor generating unit, and to reinforce the walls against the effects of the normal positive pressure within the unit as well as possible inordinate pressure surges, a buckstay system **50** comprising a plurality of structural members is provided about the exterior of the unit. It should be are recognized that the buckstay system will not be subject to the same linear thermal expansion as the walls of the vapor generator, and that provisions must therefore be made to accommodate the resulting relative movements.

In a unit of the type described above, it should be observed that the portion of each of the side walls **16** spanning the upper furnace chamber **10**, the horizontal gas pass **22** and the upper end of the convection gas pass **24** presents an extremely large continuous wall area, this area in some instances measuring nearly 100 feet in length and being about 40 feet high. With a positive fire-side pressure of 25 inches of water, this would produce a loading on a wall of this size of over 500,000 pounds under normal operating conditions. The present invention is concerned primarily with a buckstay arrangement suited to provide adequate lateral support for such a large wall area; however, it should be recognized that the invention described herein may advantageously be utilized to reinforce any wall area or any part of a vapor generating unit or other device where lateral support is required. Moreover, the description of the invention in terms of a particular vapor generating unit is not meant to serve as a limitation on this invention.

The buckstay system **50**, insofar as each of the upper side walls **16** is concerned, includes a side wall buckstay grid comprising a plurality of vertically spaced horizontal structural members **51**, which may be of any suitable cross-sectional configuration, such as I-beams. The horizontal structural members **51** are engaged (preferably by rigid attachment as by welding or bolting) at the approximate midpoint of the side wall span with a vertical structural member **52** so that the vertical structural member **52** is in lateral load bearing relationship with the horizontal structural members. The vertical structural member **52** may also be of any suitable structural shape, such as an I-beam. Additional vertical members, such as channels **53** and angle irons **54**, may also be connected between adjacent horizontal structural members to afford additional rigidity to the side wall buckstay grid. Preferably, each side wall grid is formed as a unitary structure by rigidly interconnecting the horizontal structural members **51**, a vertical structural member **52** and the additional vertical members **53** and **54**.

The use of the vertical structural member **52** at the approximate midpoint of the side wall span **51** allows the members **51** to be significantly smaller than they would be if no vertical member were used. As an example of the benefits gained by the use of the vertical structural members **52**, in a recent design study of a large vapor generator, the six horizontal buckstay members (corresponding to structural members **51**) required would have had to be 60 inch deep I-beams if no vertical member were used. By using a single 36 inch I-beam vertical member, the required width of the six horizontal buckstay I-beams was reduced to 27 inches. Thus, it can be seen that the use of a centrally disposed vertical member in conjunction with the usual horizontal members results in a significant reduction in the weight and cost of the structural steel used for a given wall buckstay system.

The vertical structural members **52** and the vertical structural members **53** and **54** are pendently supported from the top support structure **40** by means of hanger bars **55** connected to the upper ends of the vertical members **52**, **53** and **54**. Thus, where the side wall grid is formed as a rigid structure, substantially the entire weight of the grid is carried by the support bars **55** so that the wall support means are not burdened by the additional weight of the buckstay members. For reasons to be discussed hereinafter, constant-load spring supports **56** of a known type are preferably connected in load-bearing rela-

tionship between each of the hanger bars **55** and the top support structure **40**.

Due to the exposure of the wall tubes **29** of the hot gases within the unit, the side walls **16** obviously experience a significant thermal expansion between the extremes of the cold non-operating and the hot operating conditions of the unit, while the side wall buckstay grid will experience only an insignificant amount of thermal expansion since its temperature will be that of the substantially constant ambient atmosphere. Thus, provisions must be made for accommodating the relative expansion movements between the side wall **16** and the side wall buckstay grid in both the horizontal and vertical directions.

Referring to FIGS. 3A, 3B, 3C and 4, at the elevation of each of the horizontal structural members **51**, there are rigidly attached to the tubes **29** of the side wall **16** a tie bar plate **60** extending along the entire width of the wall **16** parallel to and immediately adjacent the horizontal structural member **51**. Welded to each tie bar **60** at spaced locations along its entire length is a plurality of clip assemblies **61**, each of which includes an outwardly extending vertically disposed tie plate **62** welded to the tie bar **60** and having welded thereto a pair of clips **63** which loosely engage the horizontal structural member **51** at the flange end closest to the side wall **16** (as shown in FIGS. 3A and 3C), so that the horizontal structural member **51** is restrained from movement in the direction perpendicular to the side wall **16**, while relative movement is permitted in a horizontal direction parallel to the plane of the side wall **16**. Thus, as the side wall **16** is subjected to heat and expands, relative movement with respect to the horizontal structural members **51** is allowed in the horizontal direction by virtue of the sliding engagement between the flange of the horizontal structural members **51** and the clip assemblies **61** which are secured to the wall tubes **29** as already stated.

Horizontal structural member (designated **51F** for purposes of identification in FIGS. 2, 3B and 4) is rigidly fixed to the side wall **16** so that there is no relative vertical movement between the buckstay grid and the side wall **16** at the elevation of the horizontal structural member **51F**. As shown in FIGS. 3B and 4, the tie assembly **65** connecting the horizontal structural member **51F** to the side wall **16** includes a pair of spaced, vertical angle members **66**, which have welded to the upper and lower ends thereof pairs of tie clips **67** which engage the flange end of the welded structural member **52** and also fit tightly against the top and bottom edges of the inner flange end of the horizontal structural member **51F**, thus restrainiing the horizontal structural member **51F** from vertical movement relative to the side wall **16**. By virtue of the connection between the tie clips **67** and the vertical structural member **52**, the vertical structural member **52** is also restrained from movement in a horizontal direction relative to the side wall **16**, so that all such movement is accommodated in opposite directions on opposite sides of the vertical structural member **52**. Tie rods **68** are welded between each pair of tie clips **67** immediately adjacent the flange end of the vertical structural member **52**, so as to position the buckstay grid in a direction perpendicular to the side wall **16**. Thus, it can be seen that at the junction of the vertical structural member **52** and the horizontal structural member **51**, the side wall **16** is rigidly tied to the side wall buckstay grid so that substantially no relative movement is allowed therebetween in any direction.

Since relative vertical movement between the side wall **16** and the buckstay grid is prohibited at the elevation of the horizontal structural member **51F**, it follows that relative vertical movement above and below this elevation will be in opposite directions. Accordingly, clearances are provided in the clip assemblies **61** to allow the necessary relative vertical movement. Referring particularly to FIGS. 3A and 3B, which illustrate the typical clearance arrangements for the clip assemblies **61** attached to the horizontal structural members **51** respectively above and below the horizontal structural member **51F**, it should be noted that the clearance space **64A** (FIG. 3A) is at the bottom of its respective horizontal structural member flange, while the clearance space **64B** (FIG. 3C) is at the top of its respective horizontal structural member flange. It should be recognized that the horizontal structural members **51** more distant from the fixed horizontal structural member **51F** will require larger clearance spaces than the horizontal structural members **51** that are closest to the horizontal structural member **51F**. As to the connection of the vertical structural member **52** to the side wall **16** at elevations of the horizontal structural members **51** other than the horizontal structural member **51F**, the necessary vertical relative movement can be accommodated in tie clip assemblies of the type shown as **65** by the appropriate positioning of the pairs of tie clips **67** to provide the proper clearance spaces above or below the flange ends of the horizontal structural members **51**.

Thus, by attaching the side wall buckstay grid to the side wall **16** as described above, the relative expansion movements in the horizontal and vertical directions parallel to the plane of the side wall **16** may be readily accommodated. In this regard, it should be noted that the independent support of the buckstay grid by hanger bars **55** is not materially effected by the thermal expansion of the side wall **16** and the attendant relative vertical movements of the side wall **16** and buckstay grid because of the operation of the constant-load spring supports **56**. Thus, even though the buckstay grid, by virtue of its rigid connection to the side wall **16** at the elevation of the horizontal structural member **51F**, does move downwardly upon the expansion of the side wall **16**, the constant-load spring supports are constructed so as to continue carrying the same load.

It should be recognized that the above description is merely illustrative and that the present invention is not confined to the specific construction whereby the side wall **16** is rigidly connected in a vertical direction to the particular horizontal structural member **51F**. Any of the other horizontal structural members **51** could be used as the zero relative movement elevation simply by providing the proper clip assembly arrangement with appropriate clearance spaces. For example, if so desired, the uppermost horizontal structural member **51** could be rigidly tied to the side wall **16** (in the same manner disclosed above with respect to the horizontal structural member **51F**) to preclude vertical movement therebetween, in which instance all of the clip assemblies **61** on the other horizontal structural members **51** would be constructed with clearance spaces **64B** substantially as shown in FIG. 3C.

In addition to the side wall buckstay grids discussed above, the buckstay system **50** includes horizontally disposed end wall buckstay members **71** which are interconnected at their ends through corner tie assemblies **72** to the ends of the horizontal structural members **51** so that in substance the horizontal buckstay members of the unit extend completely therearound. The corner tie assemblies may suitably be of the type disclosed in the aforementioned U.S. Patent 3,007,455. Since the end walls (furnace chamber front end wall **12** and convection gas pass rear end wall **28**) generally are not so wide as the side walls **16**, it is normally not necessary to use the type of buckstay grid system herein disclosed on the end walls. In the embodiment shown, the end wall members are attached to the end walls **12** and **28** in the usual manner (as disclosed in U.S. Patent 3,007,455) so that the weight of the members **71** is carried by the end walls **12** and **28**. The differential expansion movements between the end wall buckstay members **71** and the horizontal structural members **51** of the side wall buckstay grid may suitably be accommodated by providing adequate pivotal clearances in the corner tie assemblies **72**.

Additional lateral support is afforded the side walls **16** by virtue of the rigid side-to-side interconnection of the

vertical structural members 52. The upper tie bars 57 extend between the upper ends of the vertical structural members 52 at an elevation immediately above the roof 18 and within the penthouse enclosure 11 (see FIG. 1), so that the upper tie bars 57 experience substantially the same linear thermal horizontal expansion as do the end walls 12 and 28. The lower tie bars 58 (see FIG. 2) extend between the lower ends of the vertical structural members 52 at an elevation immediately below the floor 23 of the horizontal convection pass 22. Linear thermal expansion of the lower tie bars 58 may be substantially equalized with that of the end walls 12 and 28, by placing the lower tie bars 58 in intimate contact with the tubular heating surface of the floor 23, and by enclosing the lower tie bars 58 within suitable insulation.

While in accordance with the provisions of the statutes there is illustrated and described herein a specific embodiment of the invention, those skilled in the art will understand that changes may be made in the form of the invention covered by the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of the other features.

What is claimed is:

1. A fluid heating unit comprising a pair of spaced upright walls defining therebetween a heating chamber wherein the flow of hot combustion gases is confined, a rigid support structure extending above said heating chamber, support rods interconnecting said support structure and said walls for the pendent support thereof, a buckstay system disposed outside of said heating chamber for providing lateral support and reinforcement to said walls, said walls and said buckstay system being subject to different rates of linear thermal expansion, said buckstay system including a grid adjacent each of said walls, each of said grids including a horizontal structural member and at least one vertical structural member engaged with said horizontal structural member at the approximate midpoint of the adjacent wall, means restraining said grids from movement away from said walls, means rigidly connecting one of said grids with its adjacent wall at one location, and means permitting relative vertical movement between said one grid and its adjacent wall in opposite directions above and below the location of the connection.

2. A fluid heating unit comprising a pair of spaced upright parallel walls defining therebetween a heating chamber wherein the flow of hot combustion gases is confined, a rigid support structure extending above said heating chamber, support rods interconnecting said support structure and said walls for the pendent support thereof, a buckstay system disposed outside of said heating chamber for providing lateral support and reinforcement to said walls, said walls and said buckstay system being subject to different rates of linear thermal expansion, said buckstay system including a grid adjacent each of said walls, each of said grids including a plurality of vertically spaced horizontal structural members, and at least one vertical structural member rigidly attached with said horizontal structural members at the approximate midpoint of the adjacent wall, means rigidly connecting one of said grids to its adjacent wall at one location on said wall, and means permitting relative expansion between said one grid and its adjacent wall in directions substantially radial with respect to said one location and in a plane parallel to the wall.

3. A fluid heating unit comprising a pair of spaced upright walls defining therebetween a heating chamber wherein the flow of hot combustion gases is confined, a rigid support structure extending above said heating chamber, support rods interconnecting said support structure and said walls for the pendent support thereof, and a buckstay system for providing lateral support and reinforcement to said walls, said walls and said buckstay system being subject to different rates of linear thermal expansion, said buckstay system including a grid adjacent each of said walls, each of said grids including a plurality of vertically spaced horizontal structural members, and at least one vertical structural member, means attaching said horizontal structural members to one of said walls for permitting relative movement between said one wall and said horizontal structural members in a horizontal direction parallel to the plane of said one wall, means rigidly attaching only one of said horizontal structural members to said vertical structural member and to said one wall, thereby fixing the relative vertical positions of said one wall with respect to said vertical structural member and said one horizontal structural member at one elevation, means for pendently supporting said vertical structural member from said support structure, said vertical structural member being engaged with the remainder of said horizontal structural members, and rigid side-to-side tie members extending transversely between said walls outside of said heating chamber and interconnecting the vertical structural members disposed adjacent opposite walls and restraining said vertical structural members from movement away from said walls.

4. A fluid heating unit comprising a pair of spaced upright parallel walls defining therebetween a heating chamber wherein the flow of hot combustion gases is confined, a rigid support structure extending above said heating chamber, support rods interconnecting said support structure and said walls for the pendent support thereof, a buckstay system disposed ouside of said heating chamber for providing lateral support and reinforcement to said walls, said walls and said buckstay system being subject to different rates of linear thermal expansion, said buckstay system including a grid adjacent each of said walls, each of said grids including a plurality of vertically spaced horizontal structural members, and at least one vertical structural member rigidly attached with said horizontal structural members at the approximate midpoint of the adjacent wall, clip means connecting each of said grids to their adjacent walls, said clip means being constructed and arranged to permit relative transverse movement between each grid and its adjacent wall, to fix the relative vertical positions of each grid and its adjacent wall at one elevation adjacent said wall, and to permit relative vertical movement between each grid and its adjacent wall in opposite vertical directions respectively above and below said one elevation, and rigid tie members extending transversely between said walls and interconnecting said grids for restraining said grids from movement away from said walls.

5. A fluid heating unit comprising a pair of spaced upright parallel walls defining therebetween a heating chamber wherein the flow of hot combustion gases is confined, a rigid support structure extending above said heating chamber, support rods interconnecting said support structure and said walls for the pendent support thereof, a buckstay system disposed outside of said heating chamber for providing lateral support and reinforcement to said walls, said walls and said buckstay system being subject to different rates of linear thermal expansion, said buckstay system including a grid adjacent each of said walls, each of said grids including a plurality of vertically spaced horizontal structural members, and at least one vertical structural member rigidly attached with said horizontal structural members at the approximate midpoint of the adjacent wall, slotted clip means connecting said horizontal structural members with their adjacent wall and slidably engaging said horizontal structural members in a horizontal direction parallel to the plane of said wall, said slotted clip means including first clips fixing the relative vertical position of an intermediate one of said horizontal structural members with its adjacent wall, second clips formed with clearance spaces for permitting relative vertical movement in one direction between said wall and those of said horizontal structural members above said one

horizontal structural member, and third clips formed with clearance spaces for permitting relative vertical movement in the other direction between said wall and those of said horizontal structural members below said one horizontal structural member, and rigid tie members extending transversely between said walls and interconnecting said grids for restraining said grids from movement away from said walls.

6. A fluid heating unit comprising a pair of spaced upright parallel walls defining therebetween a heating chamber wherein the flow of hot combustion gases is confined, a rigid support structure extending above said heating chamber, support rods interconnecting said support structure and said walls for the pendent support thereof, a buckstay system disposed outside of said heating chamber for providing lateral support and reinforcement to said walls, said walls and said buckstay system being subject to different rates of linear thermal expansion, said buckstay system including a grid adjacent each of said walls, each of said grids including a plurality of vertically spaced horizontal structural members, and at least one vertical structural member rigidly attached with said horizontal structural members at the approximate midpoint of the adjacent wall, clip means connecting each of said grids to their adjacent walls, said clip means being constructed and arranged to permit relative transverse movement between each grid and its adjacent wall, to fix the relative vertical positions of each grid and its adjacent wall at one elevation adjacent said wall, and to permit relative vertical movement between each grid and its adjacent wall in opposite vertical directions respectively above and below said one elevation, means for pendently supporting the weight of said grids from said support structure substantially independently of the support of said walls, and means restraining said grids from movement away from said walls.

7. A fluid heating unit comprising walls defining an upright furnace chamber wherein fuel is consumed to produce hot combustion gases, walls defining an upright convection gas pass adjacent said furnace chamber, means interconnecting the upper portions of said furnace chamber and said convection gas pass for the flow of said gases from said furnace chamber to said convection gas pass, and means including a pair of spaced, upright, parallel side-walls common to said furnace chamber and said convection pass, a rigid support structure extending above said furnace chamber and said convection gas pass, support rods interconnecting said support structure and said side-walls for the pendent support thereof, and a buckstay system for providing lateral support and reinforcement to said side-walls, said side-walls and said buckstay system being subject to different rates of linear thermal expansion, said buckstay system including a grid adjacent each of said side-walls, each of said grids including a plurality of vertically spaced horizontal structural members, and at least one vertical structural member engaged with said horizontal structural members at the approximate midpoint of the adjacent wall and a rigid tie member extending transversely between said side-walls and interconnecting said grids for restraining said grids from movement away from said side-walls, said tie members being disposed between said furnace chamber and said convection gas pass and being installed so as to be substantially heated by said gases.

8. A fluid heating unit comprising walls defining an upright furnace chamber wherein fuel is consumed to produce hot combustion gases, walls defining an upright convection gas pass adjacent said furnace chamber, means interconnecting the upper portions of said furnace chamber and said convection gas pass for the flow of said gases from said furnace chamber to said convection gas pass, said means including a pair of spaced, upright, parallel side-walls common to said furnace chamber and said convection pass, a rigid support structure extending above said furnace chamber and said convection gas pass, support rods interconnecting said support structure and said side-walls for the pendent support thereof, and a buckstay system for providing lateral support and reinforcement to said side-walls, said buckstay system including a grid adjacent each of said side-walls, each of said grids including a plurality of vertically spaced horizontal structural members, and at least one vertical structural member, means attaching said horizontal structural members to one of said side-walls for permitting relative movement between said one side-wall and said horizontal structural members in a horizontal direction parallel to the plane of said one side-wall, means rigidly attaching only one of said horizontal structural members to said vertical structural member and to said one side-wall, thereby fixing the relative vertical positions of said one side-wall with respect to said vertical structural member and said one horizontal structural member at one elevation, means for pendently supporting said vertical structural member from said support structure, said vertical structural member being engaged with the remainder of said horizontal structural members, and rigid side-to-side tie members extending transversely between said side-walls outside of said heating chamber and interconnecting the vertical structural members disposed adjacent opposite side-walls and restraining said vertical structural members from movement away from said side-walls.

9. A fluid heating unit comprising walls defining an upright furnace chamber wherein fuel is consumed to produce hot combustion gases, walls defining an upright convection gas pass adjacent said furnace chamber, means interconnecting the upper portions of said furnace chamber and said convection gas pass for the flow of said gases from said furnace chamber to said convection gas pass, said means including a pair of spaced, upright, parallel side-walls common to said furnace chamber and said convection pass, a rigid support structure extending above said furnace chamber and said convection gas pass, support rods interconnecting said support structure and said side-walls for the pendent support thereof, and a buckstay system for providing lateral support and reinforcement to said side-walls, said buckstay system including a grid adjacent each of said side-walls, each of said grids including a plurality of vertically spaced horizontal structural members, and at least one vertical structural member rigidly attached with said horizontal structural members at the approximate midpoint of the adjacent wall, slotted clip means connecting said horizontal structural members with their adjacent side-walls and slidably engaging said horizontal structural members in a horizontal direction parallel to the plane of said side-wall, said slotted clip means including first clips fixing the relative vertical position of an intermediate one of said horizontal structural members with its adjacent side-wall, second clips formed with clearance spaces for permitting relative vertical movement in one direction between said side-wall and those of said horizontal structural members above said one horizontal structural member, and third clips formed with clearance spaces for permitting relative vertical movement in the other direction between said side-wall and those of said horizontal structural members below said one horizontal structural member, and rigid tie members extending transversely between said side-walls and interconnecting said grids for restraining said grids from movement away from said side-walls.

10. A fluid heating unit comprising walls defining an upright furnace chamber wherein fuel is consumed to produce hot combustion gases, walls defining an upright convection gas pass adjacent said furnace chamber, means interconnecting the upper portions of said furnace chamber and said convection gas pass for the flow of said gases from said furnace chamber to said convection gas pass, said means including a pair of spaced,

upright, parallel side-walls common to said furnace chamber and said convection pass, said side-walls comprising a plurality of upright fluid-cooled tubes interconnected along their lengths to form gas impervious panels, a rigid support structure extending above said furnace chamber and said convection gas pass, support rods interconnecting said support structure and said side-walls for the pendent support thereof, and a buckstay system for providing lateral support and reinforcement to said side-walls, said side-walls and said buckstay system being subjected to different rates of linear thermal expansion, said buckstay system including a grid adjacent each of said side-walls, each of said grids including a plurality of vertically spaced horizontal structural members, and at least one vertical structural member rigidly attached with said horizontal structural members at the approximate midpoint of the adjacent wall, slotted clip means connecting said horizontal structural members with their adjacent side-wall and slidably engaging said horizontal structural members in a horizontal direction parallel to the plane of said side-wall, said slotted clip means including first clips fixing the relative vertical position of an intermediate one of said horizontal structural members with its adjacent side-wall, second clips formed with clearance spaces for permitting relative vertical movement in one direction between said side-wall and those of said horizontal structural members above said one horizontal structural member, and third clips formed with clearance spaces for permitting relative vertical movement in the other direction between said side-wall and those of said horizontal structural members below said one horizontal structural member, means for pendently supporting the weight of said grids from said support structure substantially independently of the support of said side-walls, and rigid tie members extending transversely between said side-walls and interconnecting said grids for restraining said grids from movement away from said side-walls.

11. The invention according to claim **1** wherein the location of the connection of the grid to the walls is at the junction of said vertical and horizontal structural members.

12. The fluid heating unit according to claim **11** further including means for pendently supporting the weight of said grids from said support structure substantially independently of the support of said walls.

13. A fluid heating unit according to claim **12** wherein the means for pendently supporting the weight of said grids include substantially constant load bearing supports.

14. The invention according to claim **2** wherein said one location is at the approximate vertical and horizontal midpoint of said wall.

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