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FURNACE WALL SUPPORT AND EXPANSION APPARATUS

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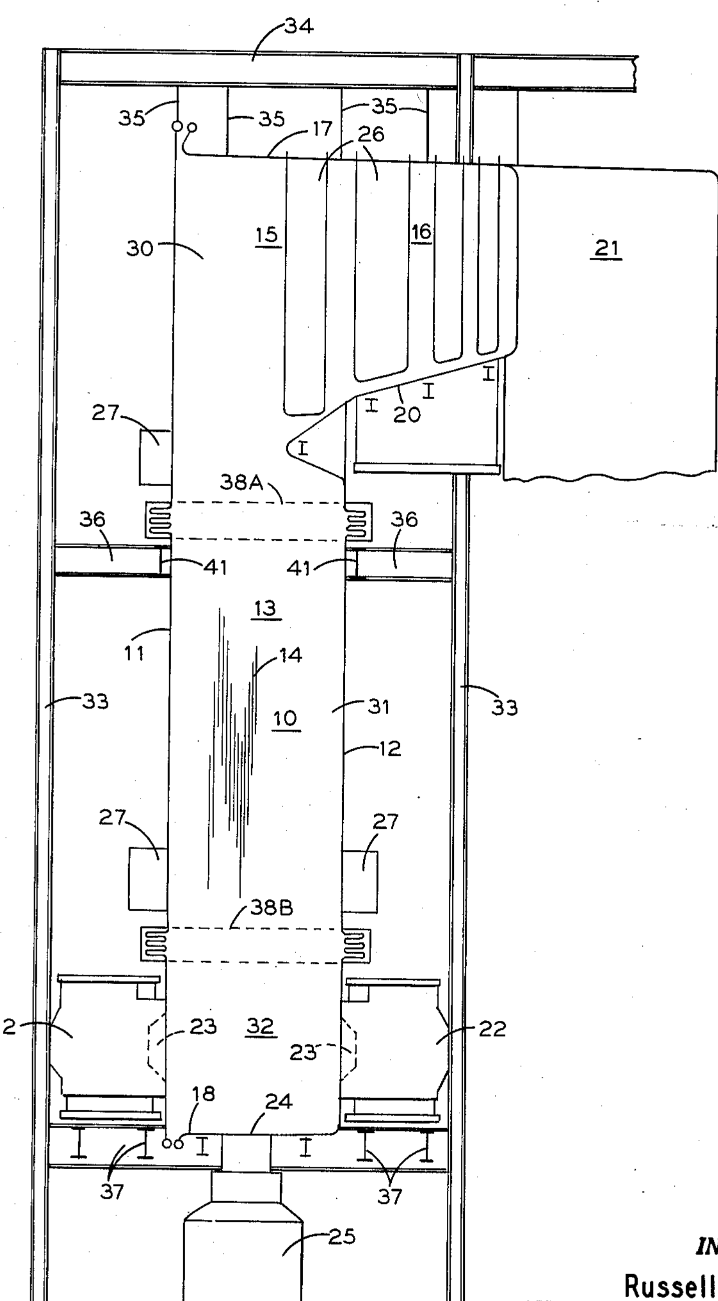
FIG. 1



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BY

ATTORNEY

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FURNACE WALL SUPPORT AND EXPANSION APPARATUS

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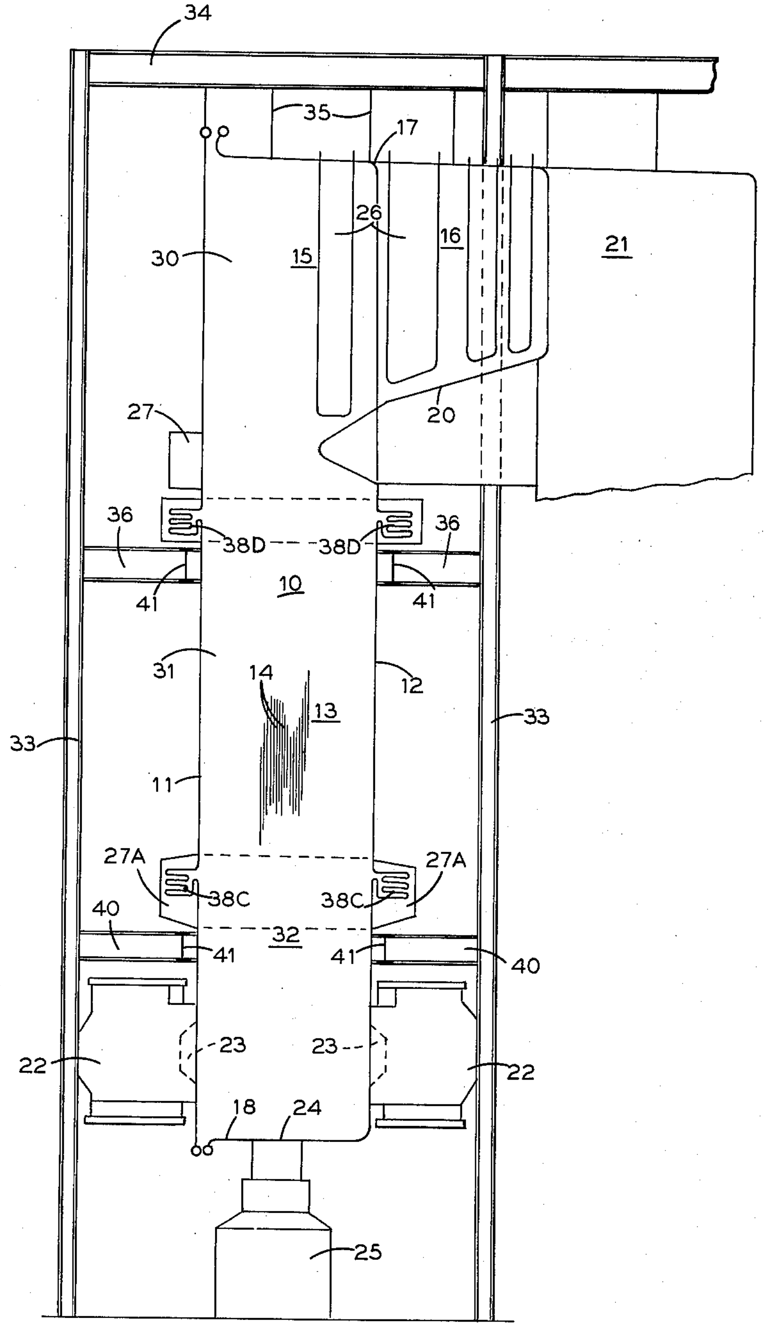
FIG. 2.



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FURNACE WALL SUPPORT AND EXPANSION APPARATUS

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FIG. 4

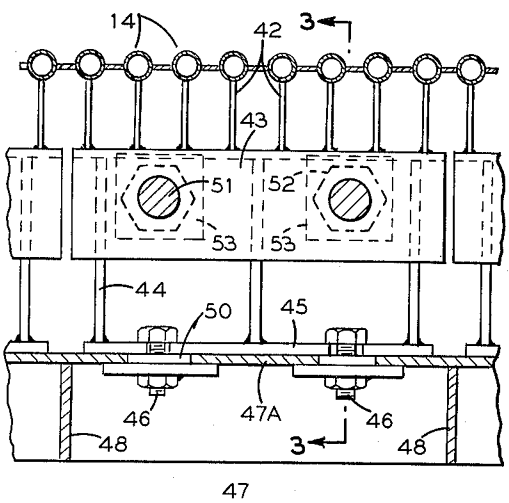

FIG. 3

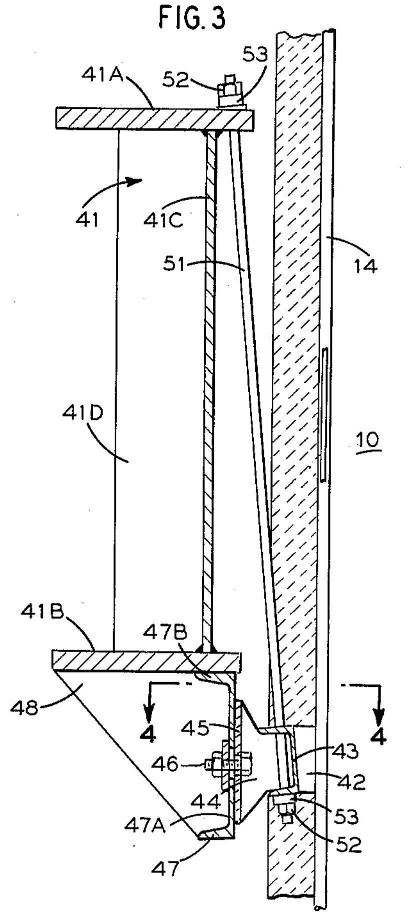

FIG. 5

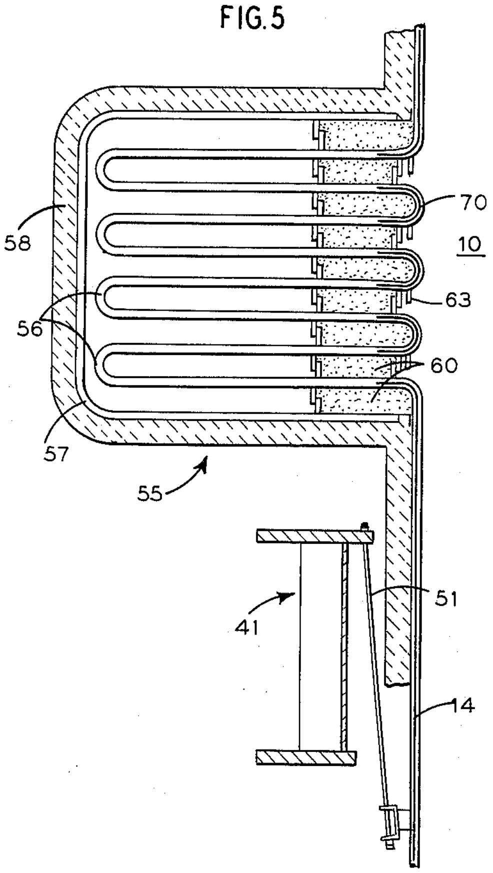

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FIG. 6

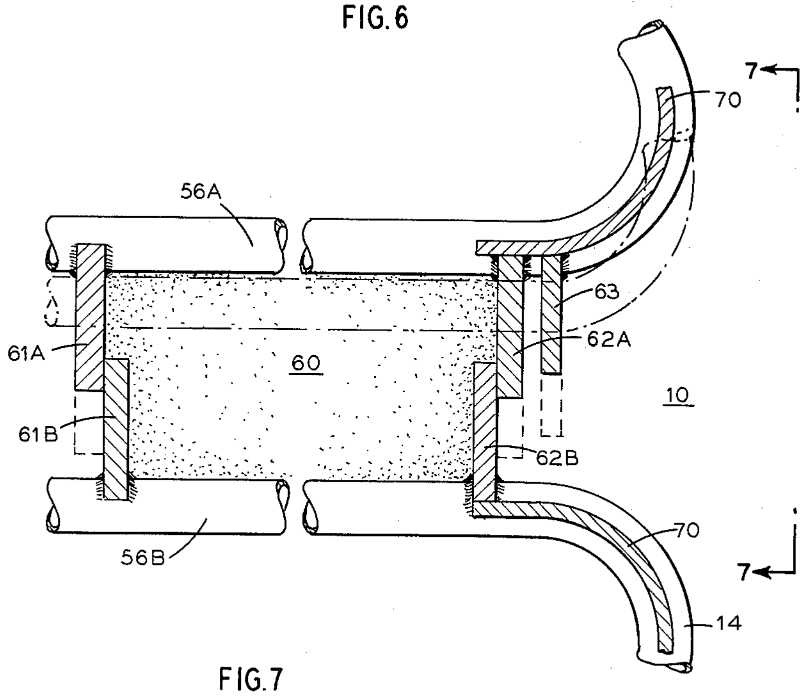

FIG. 7

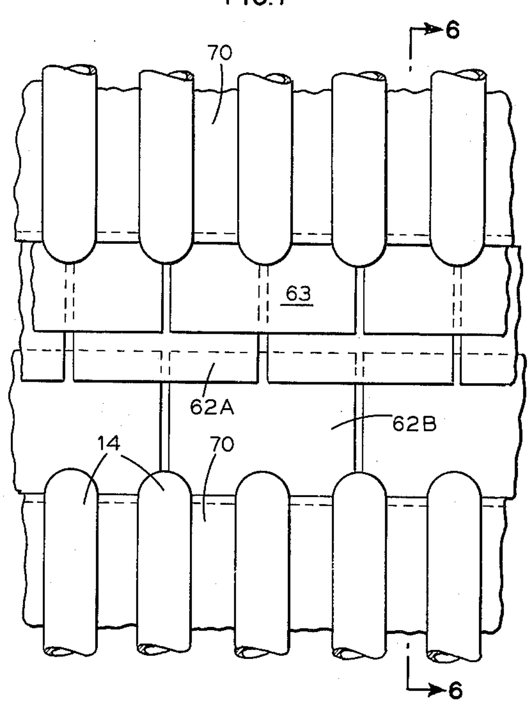

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FIG. 8

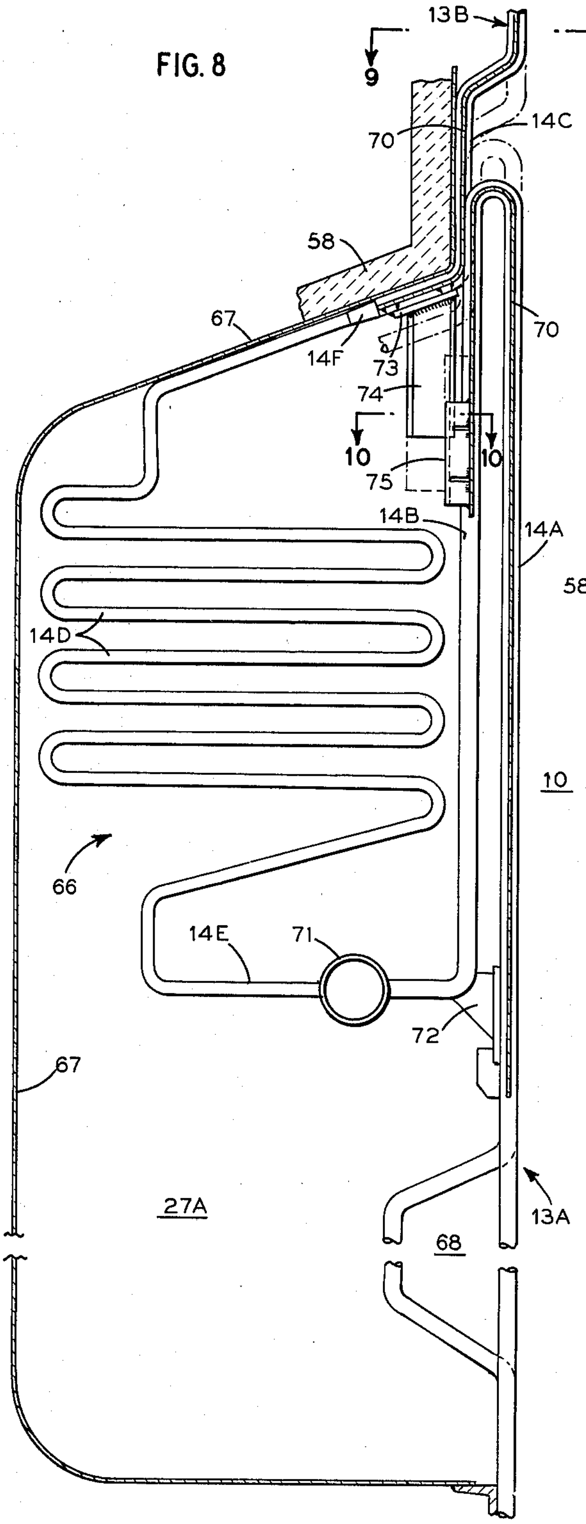


FIG. 9

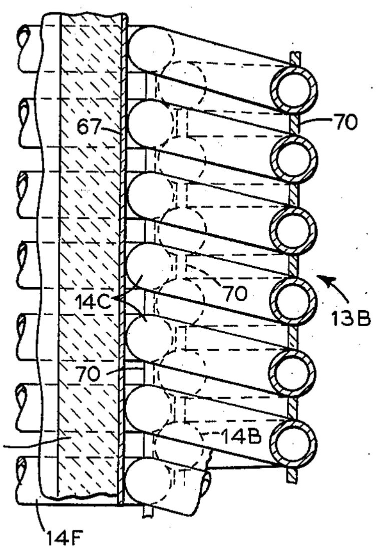
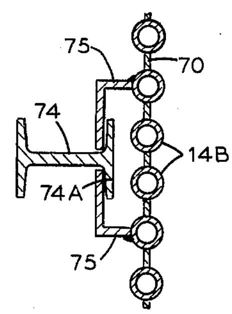


FIG. 10



3,208,436

FURNACE WALL SUPPORT AND EXPANSION APPARATUS

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Filed Dec. 20, 1962, Ser. No. 246,180
18 Claims. (Cl. 122—510)

This invention relates generally to furnaces having their inner walls lined with heat exchange tubes, and more particularly to the support and expansion apparatus associated with such furnace walls.

In recent years, economy has dictated a continual increase in the output capacity and size of vapor generating units. A large measure of the necessary capacity increase has been obtained by constructing vapor generator units in greater heights, so that today it is not uncommon for such units to be higher than 150 ft. Coincident with this increase in height there have been several other developments which complicate the support of furnace walls. Frequently, to facilitate erection, tubular furnace walls are now fabricated in panels which are assembled in the field to form pressure-tight settings. The tubes forming the walls are preferably relatively small in diameter, i.e. about 1 inch, so that the quantity of fluid contained in the generator is minimized to aid in quick start-ups and rapid response to load changes. The tendency to increase the height of furnace walls has accentuated the allowable loading limits which may be satisfactorily accommodated by the wall tubes. The increasingly more elaborate, complex, and heavy buckstay systems occasioned by this trend, the weight of the fuel burning equipment, the slag loading (when present), and the weight of the walls themselves have contributed to the problems of increased loading.

For years, the standard support system for large vapor generators has consisted mainly of top supporting the unit from a common elevation and providing for thermal expansion by downward movement of the structure. Adaptation of this system to the modern units with their greater overall height has frequently introduced difficult design problems as regards the stresses in the upper portions of the wall tubes, since they must carry their own cumulative weight in addition to the weight of buckstays, fuel burning apparatus, the fluid in the tubes, and in the case of a slagging fuel, the weight of slag deposits. Some relief may be obtained by increasing the tube sizes and/or tube wall thickness or by manufacturing the tubes of alloys having higher allowable working stress characteristics; however, these solutions are obviously costly and would tend to make a unit so designed unacceptable.

Also, in the past, it was customary to use intermediate supports for furnace walls to facilitate support of portions of the unit. This practice was particularly prevalent when furnaces included large refractory wall areas. It was then recognized that intermediate or lower supports materially reduced the quantity of structural steel necessary to support a unit of any given weight. The earlier applications of intermediate furnace supports were confined to arrangements wherein the furnace or setting walls were divided into distinct and non-continuous parts, as for example, a top supported lower refractory furnace chamber might be employed with a separate top supported upper boiler section. These arrangements which formerly were used, were found to be inadequate for the modern types of steam generators employing panel walls throughout the entire height of the furnaces, principally because of the complicated expansion problems introduced within the walls themselves.

It is therefore an object of the present invention to provide a furnace wall support and thermal expansion system whereby vapor generators can be built to almost unlimited heights without thereby incurring stress design difficulties in the furnace wall tubes. It is more particularly an object of the present invention to provide an integrated furnace wall support system employing both top and intermediate wall support structure together with the necessary provision for thermal expansion of the wall. It is a further object of this invention to reduce the quantity of structural steel necessary to support a furnace of a given weight, and to render more flexible the design of modern type vapor generating units by eliminating present known restrictions in furnace wall design imposed by stress loading considerations.

In accordance with the present invention, tubular walls formed in panels which comprise a plurality of vertically extending contiguous tubes, define a vertically elongated gas tight furnace setting which, for support purposes, is divided into a plurality of vertically overlapping sections. Each of these sections is individually and rigidly supported from a structural support system arranged adjacent the furnace. The adjacent sections are interconnected by extensions of the wall tubes which are bent outside of the confines of the furnace in sinuous paths including at least one horizontal loop to accommodate vertical expansion of the wall. The adjacent, vertically over-lapping sections may be further provided with slidable connections to permit relative vertical movement between adjacent sections.

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 drawing and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

Of the drawings:

FIG. 1 shows a typical arrangement of a furnace support and thermal expansion system;

FIG. 2 shows an alternate arrangement of a furnace support and thermal expansion system;

FIG. 3 is a sectional view of a typical intermediate wall support taken along line 3—3 of FIG. 4;

FIG. 4 is a sectional view of a wall support taken along line 4—4 of FIG. 3;

FIG. 5 is a view of a wall expansion system;

FIG. 6 is a detail view of seal plates for the wall expansion system shown in FIG. 5;

FIG. 7 is an end view of seal plates taken along line 7—7 of FIG. 6;

FIG. 8 shows the preferred embodiment of a wall expansion system;

FIG. 9 is a sectional view taken along line 9—9 of FIG. 8;

FIG. 10 is a sectional view taken along line 10—10 of FIG. 8.

In the drawings, FIGS. 1 and 2, the invention is illustrated as embodied in a cyclone-fired furnace; however, it is to be understood that the invention to be hereinafter described is not so restricted but is applicable to any elongated heating chamber having walls formed with longitudinally extending tubular members.

In FIGURE 1 is shown a modern vajor generating unit including an upright, vertically elongated furnace chamber **10** of substantially rectangular cross-section. The chamber **10** is defined by a front wall, a rear wall and side walls, **11**, **12** and **13** respectively, and a roof **17** and floor **18**. The walls **11**, **12** and **13** are formed by a plurality of vertically extending parallel tubes **14** having their intertube spaces closed by metallic webs. A gas outlet 15 at the upper end of the furnace chamber **10** opens to a horizontally extending gas pass **16** which is formed by extensions of the furnace roof **17** and side walls **13**, and an inclined floor **20**. The gas pass **16** communicates at its rear end with the upper end of a vertical gas passage **21** through which the gases subsequently leave the unit. Fuel is fired in independently operable, horizontally disposed, cyclone type furnace **22** lined by fluid heating tubes and located at the same level on opposite walls **11** and **12** in the lower portion of the furnace chamber **10**. The cyclone furnaces are carried by the furnace wall support system. Each cyclone furnace is arranged to burn fuels of the solid type at high rates of heat release and to separately discharge high temperature gaseous products of combustion into the furnace chamber **10**, and separated ash residue as a molten slag into the lower portion of the chamber **10** through openings **23** in the walls **11** and **12**. The floor **18** is formed with at east one opening **24** for the discharge of slag into a slag tank **25**. The gas pass **16** has disposed therein appropriate sections of superheater and reheater heat absorption tube banks **26**. Gas recirculation ducts **27** are provided on the furnace walls for the introduction of recirculated flue gas to the furnace chamber **10** to effect control of the steam temperature.

For purposes of support, each of the walls forming the furnace chamber **10** is divided into upper sections **30**, intermediate sections **31**, and lower sections **32**. A rigid structural steel support system for carrying the furnace walls and their appurtenances is constructed adjacent the unit and includes vertical columns **33**, horizontal top beams **34** and the necessary tie bracing (not shown). The upper wall sections **30** are suspened from top beams **34** by hanger rods **35**. The intermediate wall sections **31** are rigidy supported at the upper ends by beam systems **36** and **41** which interconnect the front, rear and side walls **11**, **12** and **13**, and the vertical columns **33**. The lower wall sections **32**, which also include for support purposes the cyclone furnaces **22**, are bottom supported by beams **37** which are connected with the upright columns **33**.

It will be recognized that the metallic walls of the furnace chamber **10** are subject to thermal expansion when the unit is fired. Expansion systems 38A and 38B are provided in the walls between the upper and intermediate wall sections **30** and **31**, and between the intermediate and lower wall sections **31** and **32** respectively to accommodate this expansion in the vertical direction. It will be appreciated that the expansion systems **38A** and **38B** are individually applied to each of the four walls of the unit. The upper wall sections **30**, being top supported by beams **34** and rods **35**, will tend to expand downwardly, as will the intermediate wall sections **31** since they are carried on beams **36**, while the lower wall sections **32** will tend to expand upwardly because of the rigid bottom support provided by beams **37**. The upper expansion system **38A** therefore accommodates the downward expansion of the upper wall sections **30**, while the lower expansion system **38B** accommodates both the downward expansion of the intermediate wall sections **31** and the upward expansion of the lower wall sections **32**.

In FIGURE 2 is shown an alternative embodiment of the present invention. As between FIGS. 1 and 2, like identification numerals indicate like parts.

The unit shown in FIG. 2 is similar to that shown in FIG. 1 with respect to the general arrangement of the furnace chamber **10**, the gas pass **16**, the gas passage **21**, and the cyclone furnaces **22**; however, the support and expansion systems differ in several respects. As in FIG. 1, the main support steel includes upright columns **33** and horizontal top beams **34** as well as hanger rods **35** to support the upper wall sections **30**. Also shown are the beams **36** supporting the intermediate wall sections **31** and an intermediate expansion system **38D**. The arrangement of FIGURE 2 differs in the support and thermal expan-

sion accommodations in that the lower wall sections **32** expand downwardly. In this instance the beams **40**, supporting the upper portion of the lower wall sections **32**, are connected to the vertical columns **33**. The expansion system **38C** shown between the intermediate and lower wall sections **31** and **32** therefore is required to accommodate only the downward expansion of the intermediate section **31**. In this embodiment the expansion system **38C** is shown as being enclosed within a gas recirculation duct **27A**, thus alleviating the expansion system seal problems as will be hereinafter described.

From the descriptions of FIGS. 1 and 2, it should be recognized that by employing the instant invention great flexibility in arrangement may advantageously be incorporated into the design and construction of modern vapor generating units. In fact, this invention is applicable in all instances where it is desired to intermediately support an elongated furnace chamber while at the same time accommodating longitudinal thermal expansion between rigid support structure.

FIGURES 3 and 4 are fragmentary views of a typical arrangement of a support system such as could be used to support the furnace walls **11**, **12** and **13**, at locations intermediate the height of the furnace chamber **10**. The main support member of the system includes shear center type girders **41** connected at their extremities and encircling the outside of the furnace walls **11**, **12** and **13**. Referring back to FIGS. 1 and 2, it can be seen that the girders **41** are appropriately connected to the vertical columns **33** by beams **36** and **40**.

The girders **41** are spaced away from the furnace walls, and are formed of a pair of spaced horizontally disposed top and bottom plates **41A** and **41B** respectively, and an interconnecting main web **41C**. The longitudinally extending main web **41C** is connected to the top and bottom plates **41A** and **41B** by welding at the inner extremity of the plates, and a plurality of vertically disposed strength webs **41D** are secured along the length of the girder **41** at spaced intervals. This type of shear girder **41** has been found to be the most desirable structural member for resisting the turning moment induced in the support structure by the eccentric loading characteristically imposed by furnace walls.

Each of the wall tubes **14** is connected to a vertically disposed hanger plate **42** which is welded to channel member **43**. As shown in FIGURE 4, the channel **43** is sectionalized so that each sectioned portion is connected to a comparatively small group of adjacently positioned wall tubes **14**; e.g. eight tubes here shown. As will be described hereinafter, this sectionalized construction of the channel **43** permits independent adjustments of portions of the wall to compensate for deflection of the girder **41**. Vertically disposed back-up plates **44**, attached to the web and flanges of the channel **43**, secure the channel to a mating connecting plate **45**. The connecting plate associated with each channel section is fastened by bolts **46** to the main web **47A** of channel **47** which extends parallel to and on the under side of girder **41**. The channel **47** has one of its legs **47B** welded to the inner edge of the bottom plate **41B** of the girder **41**. Longitudinally spaced strength webs **48** are secured to the bottom plate **41B** between the girder **41** and the channel **47**. The holes **50** in the main web **47A** through which the bolts **46** are received are slotted in both the vertical and horizontal directions to allow for deflection of the girder **41** and horizontal expansion of the wall, respectively.

The sections of the channel **43** are each connected to the inwardly extending edge of the top plate **41A** of the girder **41** by one or more hanger rods **51**. At their upper ends the rods **51** are received through holes in the top plate **41A** and at their lower ends, the rods **51** pass through aligned holes in the parallel legs or flanges of the channel **43**. Both ends of the rods **51** are threaded and are fitted with nuts **52** and rocker washers **53**. By suitably adjusting the nuts **52**, the load transmitted to and carried by the support may be equally distributed among the hanger rods 51.

It will be observed that the above described intermediate support system affords an effective means of supporting the furnace wall with provisions for adjustment so that the load may be evenly distributed along the length of the girders 41.

In FIGURES 5, 6, and 7, there is shown a tube wall expansion system 55 that may be used in conjunction with the intermediate wall support system just described. In order to properly depict the relationship between the expansion system 55 and the intermediate support, in FIG. 5, a shear center type girder 41 of the type previously described is shown as being attached to the wall tubes 14 by rods 51 at a location below the expansion system 55. Each tube 14 has a portion of its length formed into a multiplicity of horizontally extending, serially connected, return bend loops 56 which provide the necessary flexibility to accommodate the vertical expansion of the wall section. As an example of the flexibility afforded by this arrangement, calculations have shown that a 3 ft. long tube loop 56 formed a 1 inch steel tube can sustain vertical deflection of about 2 inches without exceeding the bending stress limitations of the metal. Thus, it can be seen that by using multiple loops arranged as here disclosed, comparatively large thermal expansion movements may be readily accommodated.

As shown in FIG. 5, the gas tight casing 57 extends outwardly from the furnace chamber 10 and encases the entire expansion system 55. It is suitably covered on the exterior by insulating material 58. The spaces between the loops 56 are packed with high temperature insulating wool 60 near the inner ends of the loops to prevent dust infiltration into the cavity formed by the casing 57. As best shown in FIGS. 6 and 7, the insulating wool 60 is held in place by slidably engaged outer retainer plates 61A and 61B. In FIG. 6, it will be noted, that the tube loop 56 is shown in its cold or unexpanded condition and is designated as 56A, and the hot or expanded position is shown in phantom and is designated as 56A′. As shown in FIG. 6, the outer retainer plate 61A is welded to a horizontal leg 56A of the tube loop 56 so as to extend downwardly in overlapping relationship with the retainer plate 61B which is welded to the adjacently opposite leg 56B of the loop 56. Thus it can be seen that the plates, when so arranged in staggered, overlapping and slidable engagement, form a barrier to maintain the insulating wool 60 in place. The inner retainer plates 62A and 62B are similarly arranged at the innermost portions of the horizontal legs 56A and 56B respectively to hold the insulating wool 60 in place. A shielding plate 63 may also be provided to protect the retainer plate 62A from direct radiant heat and thereby prevent overheating and warping of the inner retainer plates 62A and 62B.

As best shown in FIG. 7, the inner retainer plates 62A and 62B are shaped to fit snugly against the tubes and the tube webs 70 which interconnect the tubes 14. The inner retainer plates 62A and 62B and the shielding plate 63 are formed in short sections to prevent warping and to accommodate limited lateral expansion.

Another embodiment of the expansion system is shown generally in FIGURE 8 and in detail in FIGS. 9 and 10. The expansion system 66 shown in FIGURE 8 is encased within a gas recirculation duct such as the one generally depicted as 27A in FIGURE 2. The casing 67 cooperates with the adjacent furnace wall to form the horizontally extending gas recirculation duct 27A which opens into the furnace chamber 10 through an opening 68, which is formed by wall tubes 14 which are bent out of the plane of the wall below the expansion system 66. The external surface of the duct 27A is appropriately covered with insulation 58. It will be understood that the expansion system 66 does not require that it be positioned in a gas recirculation duct, and it should be noted that it could

also be enclosed in substantially the same manner as the expansion joint 55 shown in FIG. 5. Although no intermediate support is shown in FIG. 8, it will be understood that the expansion system 66 will be employed in conjunction with an intermediate support located below the expansion system 66, similar to that shown in FIG. 3.

The expansion system 66 is hereinafter described in terms of a single wall tube 14; however, it should be recognized that all the tubes in the furnace walls 11, 12 and 13 be shaped and arranged in a similar manner to form the expansion system 66. For purposes of description the expansion system is disclosed as being used in a side wall 13; however, it may obviously also be used in the front or rear walls 11 and 12.

The embodiment of FIGURE 8 is shown in its cold or unexpanded condition while portions of the tube outlines are also shown in phantom to represent the hot or expanded positions. In the expansion system 66, each wall tube 14 of the lower wall section 13A is formed in the shape of an inverted U having an inner leg 14A in the plane of the furnace wall 13, with a return bend connecting to an outer leg 14B disposed outside the furnace chamber 10. The corresponding portion of wall tube 14 of the upper wall section 13B is formed with an outwardly recessed portion 14C which overlaps the uppermost or return bend portion of the inverted U bend. External of the wall 13, the tube 14 is formed with a plurality of substantially co-planar, serially connected return bend, horizontal loops 14D which interconnect the recessed tube portion 14C and the lower end of the outer leg 14B.

The legs 14A and 14B of the inverted U are connected by tie plates 72 at their lower extremities and the upper portion of the outer leg 14B is slidably connected with the overlapping recessed portion 14C, as will be described hereinafter, to retain rigidity of the expansion system 66 and render it self-supporting.

The lowest horizontal tube portions 14E are connected to a header 71, which also receives the tube portions 14B, the common junction thereby affording facility for drainage (not shown).

As previously mentioned, the intertube spaces of the furnace walls 11, 12 and 13 are provided with interconnecting metallic webs 70 to form an imperforate panel or membrane type wall. This same type of construction is included for the portions of the expansion system 66 which form the exposed portions of the furnace wall 13. As best shown in FIGS. 8, 9 and 10, web members 70 are provided in the intertube spaces of the lower wall section 13A over the entire length of the inner legs 14A, around the curved section of the inverted U bends, and part of the way down the outer legs 14B. Web members 70 are also provided in the intertube spaces of the upper wall section 13B to a point down past the recessed tube portions 14C.

As best shown in FIGS. 8 and 9, the recessed portions 14C are offset out of their normal planes so that they register with the intertube spaces of the over-lapping outer leg portions 14B which are in the normal wall tube plane as defined by the axes of inner and outer legs 14A and 14B. This construction minimizes the open area between the overlapping portions of the upper and lower wall sections 13B and 13A. It should be recognized that the tube 14 must be bent back into its normal plane. This can be done any place within the horizontal loops 14D, for example in the lowest tube portion 14E.

The slidable engagement between the recessed portion 14C and the inner leg 14B is shown on FIGS. 8 and 10. Plate 73 is welded to the metallic webs 70 at a location near the top of the sloped tube portions 14F. A vertical I-beam 74 is attached to and projects vertically downwardly from the plate 73. The one flange 74A of the I-beam 74 is engaged by the legs of a pair of outstanding angle sections 75 which have their other legs welded to the tube portions 14B. The lengths of the I-beam 74 and the angle sections 75 are so sized as to permit the necessary clearance to allow relative movement between wall sections 13A and 13B.

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. In a fluid heating unit, in combination, walls defining a furnace chamber, said walls being formed in panels with a plurality of vertically extending contiguous tubes and being divided into sections at spaced locations along the height of said furnace chamber, a rigid structural support system adjacent said furnace chamber including upright steel columns and horizontally extending fixed support members rigidly attaching said columns to all of the tubes of each of said sections, and means disposed peripherally around said furnace chamber and interconnecting said sections for accommodating vertical expansion of said walls, said means including extended portions of said tubes.

2. In a fluid heating unit, in combination, longitudinally extending tubular walls defining a heating chamber, said heating chamber being divided into an end portion, an intermediate portion and an opposite end portion for support purposes, a rigid structural support system adjacent said heating chamber and including upright steel columns, first support members rigidly connecting said end portion to said columns, second support members rigidly connecting said intermediate portion to said columns, third support members rigidly connecting said opposite end portion to said structural support system, and means disposed perpherally around said heating chamber and being constructed and arranged between said end portion and said intermediate portion and between said intermediate portion and said opposite end portion for accommodating expansion of said tubular walls.

3. In a fluid heating unit, in combination, longitudinally extending vertical tubular walls defining a heating chamber, said heating chamber being divided into an upper portion, an intermediate portion and a lower portion for support purposes, a rigid structural support system adjacent said heating chamber for carrying the weight of said walls, first support members rigidly connecting said upper portion to said structural support system, said upupper portion being top supported, second support members rigidly connecting said intermediate portion to said structural support system, said intermediate portion being top supported, third support members rigidly connecting said lower portion to said structural support system, said lower portion being bottom supported, means constructed and arranged between said upper portion and said intermediate portion to accommodate downward expansion of said upper portion, and means constructed and arranged between said intermediate portion and said lower portion to accommodate downward expansion of said intermediate portion and upward expansion of said lower portion.

4. In a fluid heating unit, in combination, walls defining a vertically elongated furnace chamber of substantially constant cross section, said walls being formed in panels with a plurality of longitudinally extending continuous tubes and being divided into sections as spaced locations along the height of said furnace chamber, a rigid structural support system adjacent said furnace chamber, fixed support members rigidly attaching each of said sections to said support system, and means positioned intermediate said sections for accommodating longitudinal expansion of said walls, said means including adjacent intermediate portions of all of said tubes arranged and constructed in multi-looped sinuous paths.

5. In a fluid heating unit, in combination, walls defining a vertically elongated furnace chamber of substantially constant horizontal cross-section, said walls being formed with a plurality of vertically extending contiguous tubes and being divided into sections at spaced locations along the height of said furnace chamber, a rigid structural support system adjacent said furnace chamber for carrying the weight of said walls and including upright steel columns and fixed support members rigidly attaching each of said sections to said support system, and means positioned intermediate said sections for accommodating vertical expansion of said walls, said means including extended portions of all of said tubes formed in sinuous paths outside said furnace chamber and comprising at least one horizontal loop in each of said tubes.

6. In a fluid heating unit, in combination, walls defining a vertically elongated furnace chamber of substantially constant rectangular horizontal cross-section, said walls being formed with a plurality of longitudinally extending contiguous tubes and being divided into sections at spaced locations along the height of said furnace chamber, a rigid structural support system adjacent said furnace chamber, fixed support members rigidly attaching each of said sections to said support system, and means positioned intermediate said sections for accommodating longitudinal expansion of said walls, said means including extended portions of all of said tubes interconnecting said sections and being arranged and constructed in sinuous paths outside said furnace chamber in horizontal planes substantially perpendicular to the walls and vertically displaced along the furnace chamber.

7. In a fluid heating unit, in combination, walls defining a vertically elongated furnace chamber, said walls being formed in panels with a plurality of longitudinally extending contiguous tubes and being divided into overlapping sections at spaced locations along the height of said furnace chamber, a rigid structural support system adjacent said furnace chamber, fixed support members rigidly attaching each of said sections to said support system, and means interconnecting said sections for accommodating longitudinal expansion of said walls, said means including slidable connections between the overlapping portions of said sections to allow relative vertical movement therebetween.

8. In a fluid heating unit, in combination, walls defining a vertically elongated furnace chamber, said walls being formed in panels with a plurality of longitudinally extending continuous tubes and being divided into overlapping sections at spaced locations along the height of said furnace chamber, a rigid structural support system adjacent said furnace chamber, fixed support members rigidly attaching each of said sections to said support system, and means interconnecting said sections for accommodating longitudinal expansion of said walls, said means including interlocking slidable connections between the overlapping portions of said sections to allow relative vertical movement therebetween, and extended intermediate portions of said tubes arranged and constructed in sinuous paths.

9. In a fluid heating unit, in combination, walls defining an upright elongated heating chamber of substantially constant horizontal cross-section, said walls being formed in panels with a plurality of vertically extending contiguout tubes and being divided into overlapping sections at spaced locations along the height of said heating chamber, a rigid structural support system adjacent said heating chamber, fixed support members attaching each of said sections to said support system, and means interconnecting said sections for accommodating vertical expansion of said walls, said means including slidable connections between the overlapping portions of said sections to allow relative vertical movement therebetween, said means further including extended portions of said tubes arranged and constructed outside of said heating chamber in sinuout paths comprising at least one horizontal loop.

10. In a fluid heating unit, in combination, walls defining a furnace chamber, said walls being formed in panels with a plurality of vertically extending continuous tubes and being divided into sections at spaced locations along the height of said furnace chamber, a rigid structural support system adjacent said furnace chamber, fixed support members attaching each of said sections to said support system, means interconnecting said sections for accommodating vertical expansion of said walls including extended portions of said tubes arranged and constructed in sinuous paths outside said furnace chamber, and a gas recirculation system operatively associated with said furnace chamber and comprising a gas recirculation passageway formed on the outside of at least one of said walls, said passageway being constructed and arranged to enclose said extended portions of said tubes.

11. In a fluid heating unit, in combination, walls defining a gas-tight furnace chamber of substantially constant horizontal cross-section wherein fuel is consumed to produce hot combustion gases, said walls being formed with a plurality of vertically extending continuous tubes having their inter-tube spaces filled along the portions thereof which are exposed to the hot gases within said furnace chamber, a rigid structural support system adjacent said furnace chamber including upright steel columns and laterally extending fixed support members rigidly attaching said columns to said walls at spaced elevations along the height thereof, means provided in said walls between said members for accommodating vertical expansion of said walls, said last named means including intermediate portions of all of said tubes, each of said intermediate portions being displaced from its wall and bent outwardly to form a multi-looped sinuous path outside the boundaries of said furnace chamber, and means for sealing the ends of the inter-loop spaces to prevent the flow of said hot gases into said inter-loop spaces.

12. In a fluid heating unit, in combination, walls defining a gas-tight furnace chamber of substantially constant rectangular horizontal cross-section wherein fuel is consumed to produce hot combustion gases, said walls being formed with a plurality of vertically extending continuous and contiguous tubes having their inter-tube spaces filled along the portions thereof which are exposed to the hot gases within said furnace chamber, a rigid structural support system adjacent said furnace chamber and including upright steel columns and laterally extending fixed support members rigidly attaching said columns to all of said tubes in said walls at spaced elevations along the height thereof, and means provided in said walls between said members for accommodating vertical expansion of said walls, said last named means including intermediate portions of all of said tubes, each of said intermediate portions being displaced from its wall and bent outwardly to form a multi-looped sinuous path in a vertical plane substantially perpendicular to the plane of its wall.

13. In a fluid heating unit, in combination, longitudinally extending vertical tubular walls defining a heating chamber, said heating chamber being divided into an upper portion an intermediate portion and a lower portion for support purposes, a rigid structural support system adjacent said heating chamber for carrying the weight of said walls, first support members rigidly connecting said upper portion to said support system, said upper portion being top supported, second support members rigidly connecting said intermediate portion to said support system, said intermediate portion being top supported, third support members rigidly connecting said lower portion to said support system, said lower portion being top supported, means constructed and arranged between said upper portion and said intermediate portion to accommodate downward expansion of said upper portion, and means constructed and arranged between said intermediate portion and said lower portion to accommodate downward expansion of said intermediate

portion, said lower portion being free to expand downwardly.

14. In a fluid heating unit, in combination, walls defining a furnace chamber, said walls being formed with a plurality of vertically extending continuous tubes, a rigid structural support system adjacent said furnace chamber for carrying the weight of said walls, fixed support members rigidly attaching said support system to said walls at spaced elevations along the height thereof, means provided in said walls between said members for accommodating vertical expansion of said walls, said means including adjacent intermediate portions of all of said tubes, each of said intermediate portions being displaced from its wall and bent outwardly to form a sinuous path having multiple horizontal loops in a common plane perpendicular to the plane of the respective wall, and means for sealing the ends of the inter-loop spaces, said last named means including pairs of overlapping slidably engaged seal bars affixed on adjacent ones of said horizontal loops, and flexible insulating material disposed between said pairs of sealing bars, said sealing bars and insulating material cooperating to prevent the flow of hot gases from said chamber into said inter-loop spaces.

15. In a fluid heating unit, in combination, walls defining an upright elongated furnace chamber of substantially constant horizontal cross-section wherein fuel is consumed to produce hot combustion gases, said walls being formed with a plurality of vertically extending continuous tubes having their inter-tube spaces filled along the portions thereof which are exposed to the hot gases with in said furnace chamber, said walls being divided into overlapping panel sections at spaced locations along the height of said furnace chamber, a rigid structural support system adjacent said furnace chamber and including upright steel columns and laterally extending fixed support members rigidly attaching each of said panel sections to said columns, and means interconnecting said panel sections for accommodating vertical expansion of said walls including adjacent extended intermediate portions of said tubes arranged and constructed outside of said furnace chamber in planar sinuous paths comprising at least one horizontal loop and an inverted U-bend, and an inter-locking slidable connection between the overlapping portions of said sections to allow relative vertical movement therebetween.

16. In a fluid heating unit, in combination, walls defining a furnace chamber, said walls being formed with a plurality of vertically extending continuous tubes, a rigid structural support system adjacent said furnace chamber for carrying the weight of said walls, fixed support members rigidly attaching said support system to each of said tubes in said walls at more than one elevation along the height of said tubes thereby fixing the position of all of said tubes and walls at said elevations, and means positioned intermediate said members for accommodating vertical expansion of said tubes and walls between said elevations.

17. In a fluid heating unit, in combination, walls defining a fluid-tight furnace chamber wherein fuel is consumed to produce hot combustion gases, said walls being formed with a plurality of vertically extending interconnected continuous tubes extending the entire height of said furnace chamber, said tubes being rigidly interconnected with each other along the entire portions thereof which are exposed to said hot gases within said furnace chamber, a rigid structural support system adjacent said furnace chamber, fixed support members rigidly attaching said support system to each of the tubes in said walls at more than one elevation along the height of said tubes thereby fixing the position of said tubes and walls at said elevations, and means positioned intermediate said members for accommodating vertical expansion of said tubes and walls between said elevations.

18. The combination according to claim **16** wherein said means includes intermediate portions of all of said tubes forming overlapping sections for accommodating longitudinal expansion of said tubes and walls between said elevations.

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