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Lawrence, deceased

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[54] **SECTIONALIZED METAL STACK FOR HIGH TEMPERATURE SERVICE**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 27,355, April 10, 1970, Pat. No. 3,669,042.

[52] **U.S. Cl.** **110/184,** 98/60

[51] **Int. Cl.** **F23j 11/00**

[58] **Field of Search** 110/184; 98/46, 60; 126/307

[56] **References Cited**

UNITED STATES PATENTS

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Assistant Examiner—James C. Yeung
Attorney—Kurt Kelman et al.

[57] **ABSTRACT**

A steel stack for conveying hot gases consists of vertical sections which each have a tubular, upright, inner wall, a tubular, upright, outer wall spacedly surrounding the inner wall, an upper annular flange and a lower annular flange which connect the walls so as to form a sealed chamber about the inner wall. The bore of the inner wall provides a gas conduit alignedly communicating with corresponding conduits of other sections. Gas in the chamber holds heat transfer by conduction from the inner to the outer wall to a minimum. The operating temperatures are too low to cause significant heat radiation from the inner wall, and heat loss from the inner wall by convection is reduced or avoided by a layer of thermal insulation, such as glass wool, at least partly covering one of the walls in the chamber.

9 Claims, 2 Drawing Figures

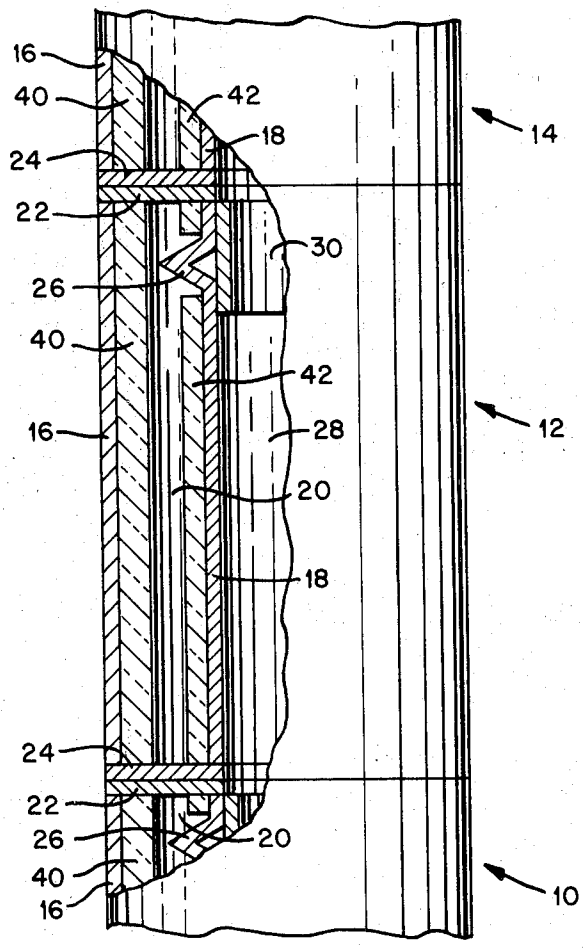


FIG. 2

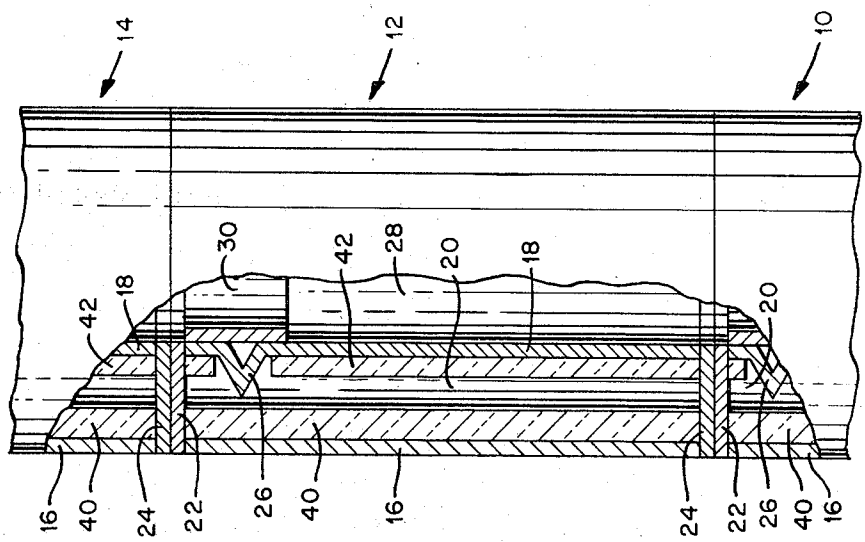
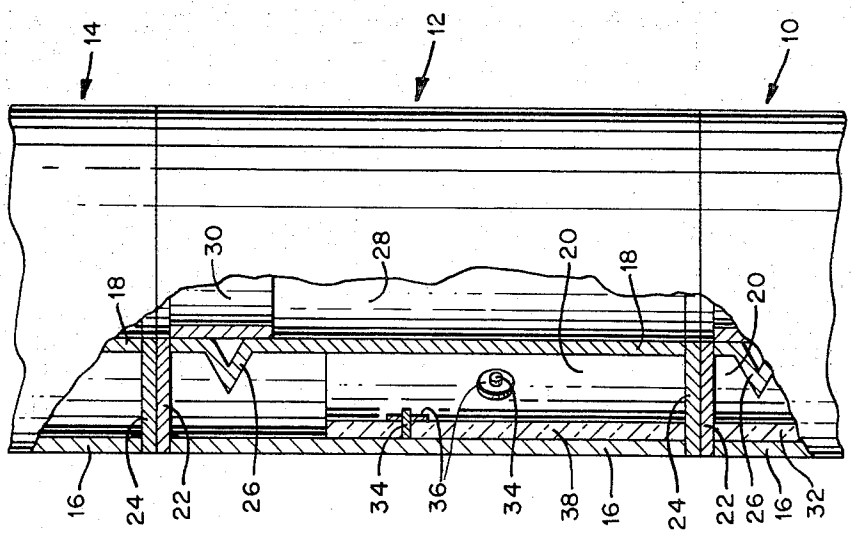

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FIG. 1


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SECTIONALIZED METAL STACK FOR HIGH TEMPERATURE SERVICE

This application is a continuation-in-part of the copending application Ser. No. 27,355, filed Apr. 10, 1970 now U.S. Pat. No. 3,669,042.

This invention relates to sectionalized stacks for conveying hot gases and particularly to an improvement in a sectionalized stack built mainly of thermally conductive material, such as steel.

It is known to assemble individual sections of a steel stack from an upright, tubular, inner wall, and upright, tubular outer wall spacedly surrounding the inner wall, and vertically to seal an air chamber between the two tubular walls by means of upper and lower flanges which connect the walls. The central cavities or bores of the respective inner walls in the several sections are vertically aligned to constitute a continuous conduit for the rising hot gases. The air chambers respectively surrounding the sections of the conduit retain the thermal energy of the gas to improve the draft of the stack, and prevent condensation of corrosive liquid from the conveyed gas on the inner stack wall.

Heat transmission by conduction between the inner and outer walls of a sectionalized stack of the type described is substantially limited to the flanges which vertically bound each chamber, but have too small a cross section to cause heat losses from the conveyed gas to the outer wall and to the ambient atmosphere that could interfere with the draft of the stack and the useful life of the stack. A normal stack is not operated at temperatures at which an inner tube of metallic material would radiate thermal energy at a significant rate.

It has now been found, however, that the body of air enclosed in the chamber of each section circulates in an approximately toroidal pattern in which it rises along the heated inner wall of the chamber and falls along the air-cooled outer wall, the flow being radially outward along the upper flange and radially inward along the lower flange. In a stack conveying gases 1,000°F and more above ambient air temperature, the heat transfer from the inner to the outer wall of each section by air convection has been found to reduce the draft measurably, to contribute to the deterioration of a paint coating on the outer surface of the stack, and otherwise to shorten the useful life of the stack. It is the primary object of this invention to suppress convection currents in the sealed chamber of a stack section as described above.

According to the instant invention, heat transfer between the inner and outer walls of the stack at high operating temperatures can be reduced sharply by lining at least a portion of one of the upright walls in the chamber with a layer of non-metallic, heat-insulating material.

The lining adds somewhat to the weight of the stack, and therefore requires suitable reinforcement of the walls. It is most advantageous, therefore, to employ as little lining material as will produce an effect economically consistent with the direct and indirect cost of lining the stack walls.

No significant reduction in heat loss by convection can be obtained unless more than one half of the face of a wall in the chamber, and preferably the outer wall of one section, is covered by the layer of heat-insulating material, and it is preferred completely to cover the face of at least one wall in at least the bottommost section, if there is relatively quick adiabatic expansion of the ascending gases in the stack, and a very high gas temperature is experienced only at the bottom of the stack.

Normally, the temperature of the gas drops gradually by expansion from the stack bottom up so that several stack sections should be lined, preferably over more than the lower half of the stack, and each section of the stack, from the lowermost to that at the top, may be provided with a liner on one of its upright walls.

When the inner wall alone is lined, the exposed face of the insulating layer becomes much hotter than the outer wall and is itself effective in promoting air convection in the sealed chamber. A layer of insulating material on an outer wall is less effectively cooled through the outer wall by the ambient atmosphere because of the smaller thermal gradient, and is thus less likely to produce a convection current in the body of gas sealed in the chamber.

Circulation is suppressed most effectively in the chamber of a section whose inner and outer walls both carry layers of thermally insulating material in the sealed chamber. Since no other practical material can rival the insulating properties of air or of a similar gas, it is essential to space the layers of insulating material horizontally apart in the sealed chamber so that the average thickness of the annular body of gas between the layers is at least equal to the thickness of one of the layers, and equal to the thickness of the thinner layer if the two layers are of different thickness.

Among thermal insulating materials commercially available at this time, blankets of felted, spun-glass fibers have been found to combine light weight, good insulating properties, and convenient handling and mounting properties in a most advantageous manner, but it should be understood that the invention is not limited to this specific material whose porous structure has been found to be a desirable feature for impeding convection currents in the sealed chamber. Blankets of fibrous asbestos and flame-sprayed coatings of ceramic material are representative of the wide range of other available thermally insulating materials.

Other features, additional objects and many of the attendant advantages of this invention will readily be appreciated as the same becomes better understood by reference to the following detailed description of preferred embodiments when considered in connection with the appended drawing in which:

FIG. 1 shows three sections of a smoke stack of the invention in fragmentary side elevation, a portion of the stack being broken away to reveal internal structure; and

FIG. 2 illustrates another stack of the invention in a view corresponding to that of FIG. 1.

Referring initially to FIG. 1, there is seen a portion of a stack of the general type more fully illustrated in the afore-mentioned copending application. The illustrated portion consists of three sections **10, 12, 14.** Each section has a tubular, outer cylindrical wall **16** and a generally cylindrical, inner, tubular wall **18** of smaller diameter coaxially received in the outer wall. An annular chamber **20** between the walls **16, 18** is axially sealed by an upper radial flange **22** and a lower axial flange **24.** The flanges **22, 24** are identical, flat discs whose central openings have a diameter equal to the central conduit or bore **28** of the inner wall **18.** The walls and flanges consist of steel and are welded to each other to seal a body of air in the chamber **20.** The sec-

tions 10, 12, 14 are connected in axially superposed relationship by welds fastening respective flanges to each other.

The inner wall 18 has an accordeon-like, circumferential fold 26 near the upper flange 22 which forms a rib on the inner wall 18 in the chamber 20 and a corresponding annular groove directed toward the central conduit 28 in the inner wall 18. The fold 26 is axially more resilient than the cylindrical main portion of the inner wall 18 and permits axial expansion of the main portion without buckling or other deformation when hot gases rise in the axially aligned central smoke conduits 28 of the several sections while the air-cooled outer walls 16 expand less or not at all. Turbulence in the rising gases at the fold 26 is practically completely prevented by a cylindrical steel apron 30 depending from the flange 22 and covering the open side of the fold.

The welded steel structure described so far is identical in each of the sections 10, 12, 14, and has been described and illustrated in the afore-mentioned copending application.

The outer wall 16 of the section 10 is covered over its entire axial length in the chamber 20 by a blanket 32 of felted, spun, glass fibers. Steel studs 34, of which only two are shown in the drawing in section 12, project from the wall 16 through the blanket 32. The studs are spaced approximately 12 inches apart in an axial and circumferential direction, and a speed washer 36 prevents slipping of the glass blanket from each stud. The mechanical strength of the blanket 32 is sufficient to prevent gradual enlargement of the openings through which the studs 34 pass.

When combustion gases rise through the aligned conduits 28 of the partially illustrated stack, the inner walls 16 are quickly heated to a temperature not much lower than that of the gases and expand, thereby compressing the folds 26. Relatively little heat is transmitted by conduction to the outer wall 16 through the flanges 22, 24 and through the body of air trapped in the chamber 20. However, the air adjacent the inner wall 18 is heated, expands, and starts circulating because the heavier, cooler air along the surface of the yet unheated blanket 32 descends. Heat is thus transferred from the hot inner wall 18 to the inner face of the blanket 32 in the chamber 20 while the outer face of the blanket is cooled by ambient air through the contacting metal of the outer wall 16. Ultimately, a steady state is reached in which the air circulation in the chamber 20 of the section 10 is reduced to a velocity consistent with the temperature differential between the inner wall 18 and the inner face of the blanket 32 which is much hotter than the outer blanket face and the outer wall 16.

A glass fiber blanket whose radial thickness is only a small fraction of the radial width of the chamber 20, and which covers the entire outer wall 16, can reduce heat transfer to the outer wall 16 from the inner wall 18 by convection to an insignificant value under many conditions of stack operation. Such a blanket is partly shown in section 10.

The outer wall of the air chamber in section 12 is covered with a glass fiber blanket 38 to approximately two thirds of its axial height, an arrangement which has a significant effect on heat loss by convection in the air chamber, and the section 14 is unlined. The sections 10, 12, 14, as shown, are representative of the transition between a lined and an unlined axial portion of a stack, the lined portion constituting the lower two thirds of the partly illustrated stack.

FIG. 2 illustrates a stack adapted for conveying extremely hot gases. Its steel structure is identical with that shown in FIG. 1. The same reference numerals designate corresponding elements which will not be described again. The stack partly shown in FIG. 2 consists of sections whose outer walls 16 are lined by respective heavy glass fiber blankets 40, whereas the cylindrical portions of the inner walls 18 are covered by thinner blankets 42, the blankets being fastened by non-illustrated studs 34 and washers 36, as described with reference to FIG. 1. The annular body of air which separates the blankets 40, 42 is radially wider than the blanket 42, but narrower than the blanket 40. An arrangement of the type illustrated in FIG. 2 has been found effective in practically entirely suppressing heat loss from the inner wall 18 by convection in the chamber 20 at all temperatures of the stack gas for which a steel stack is practical, and even at very low ambient temperature.

While the invention has been described above with reference to stacks having coaxial, cylindrical, outer and inner walls, it is equally applicable to stacks in which the outer and/or the inner walls are of non-circular cross section, and in which one outer wall encloses several inner walls bounding respective upright gas conduits. If the several conduits convey gases greatly differing in temperature, and if heat exchange between these gases in the stack is undesirable, layers of heat insulating material may be provided on one or more inner walls, as needed, in a manner obvious from the description of FIGS. 1 and 2.

It should be understood, therefore, that the foregoing disclosure relates only to preferred embodiments of the invention, and that it is intended to cover all changes and modifications of the examples of the invention herein chosen for the purpose of the disclosure which do not constitute departures from the spirit and scope of the invention set forth in the appended claims.

What is claimed is:

1. A stack comprising, in combination:

a. a plurality of sections fastened to each other in vertical alignment,

1. each section having an outer, tubular, upright wall and an inner, tubular, upright wall, said walls being of thermally conductive material, an upper annular flange and a lower annular flange connecting the inner and outer walls, said flanges and said walls jointly bounding a sealed space, and said inner wall bounding a conduit alignedly communicating with respective conduits in other sections,

2. said inner wall being formed with a resiliently deformable, accordeon-like, circumferential fold permitting thermal expansion and contraction of said inner wall at a rate different from the rate of thermal expansion and contraction of said outer wall; and

b. a layer of solid, heat insulating material covering more than one half of the face of at least one of said walls in said sealed space of at least one section.

2. A stack as set forth in claim 1, wherein said layer substantially completely covers said face of said at least one wall.

3. A stack as set forth in claim 2, wherein said layer substantially completely covers said face of said at least one wall in each of said sections.

4. A stack as set forth in claim 3, wherein said one wall is said outer wall.

5. A stack as set forth in claim 3, wherein said thermally conductive material is metallic.

6. A stack as set forth in claim 5, wherein the layers of said heat insulating material extend over substantially more than one half of the height of said stack.

7. A stack as set forth in claim 1, further comprising another layer of solid, heat insulating material on the other one of said walls of said one section, said layers being horizontally spaced from each other and a body of air extending between said layers, the thickness of said body of air in a direction from one layer to the other layer being at least equal to the thickness of one of said layers in said direction.

8. A stack as set forth in claim 1, a body of a gas in said chamber, said layer having a porous face directed away from said at least one wall.

9. A stack as set forth in claim 8, wherein said layer constitutes a cohering blanket of fibers, and means securing said blanket in direct contact with said at least one wall, said porous face being exposed to said gas.

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