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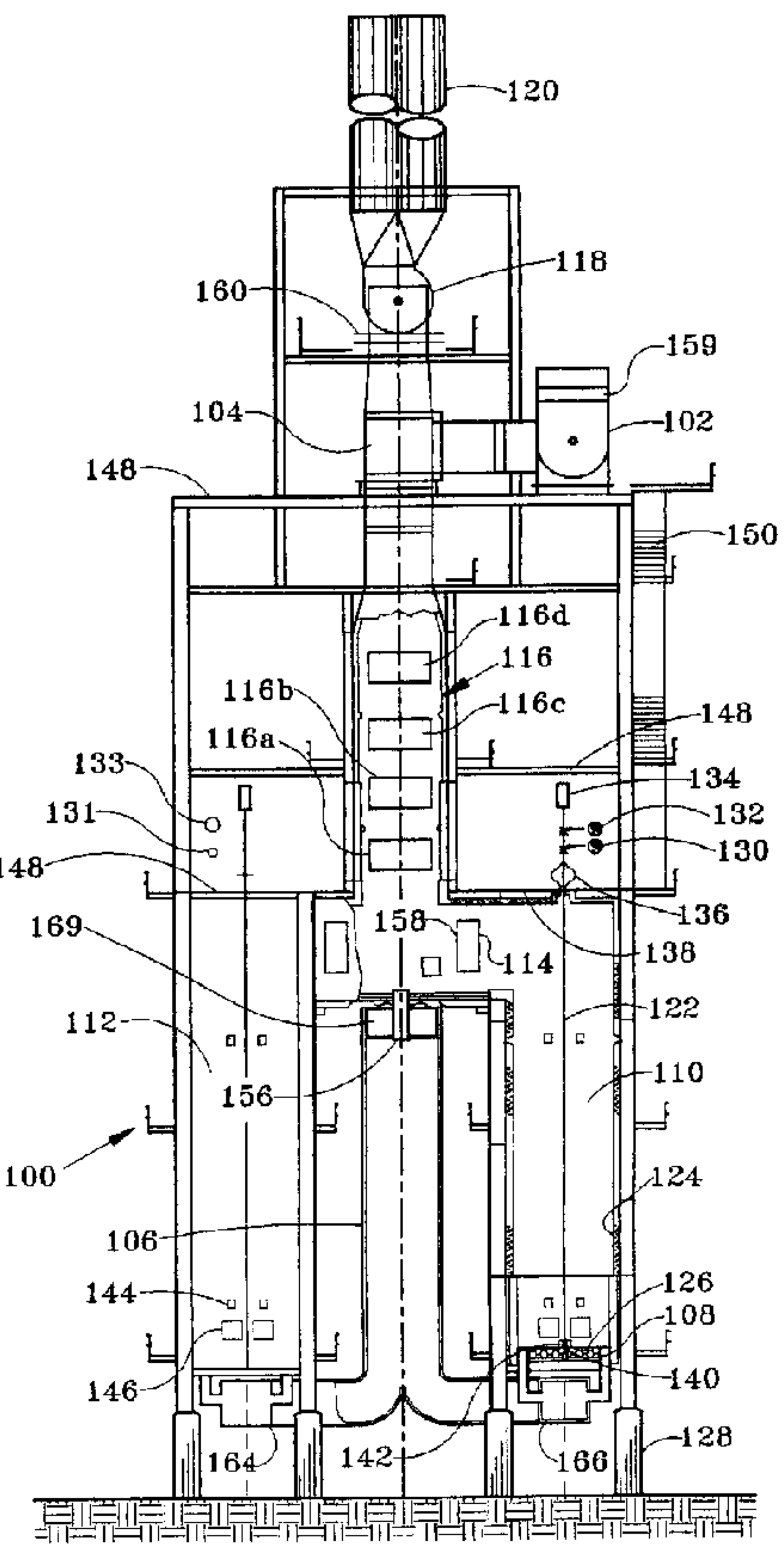
(54) **APPAREIL DE CHAUFFAGE INDUSTRIEL**
(54) **PROCESS FURNACE**



(57) A twin-cell furnace for process stream preheat and utility steam superheat. The furnace uses a pair of vertical radiant cells with top supported, bottom guided, single row, multiple pass vertical coils fired on opposite sides by floor-mounted burners. An overhead convection section is centered between the radiant cells. Induced and forced draft fans are placed over the convection section to draw combustion gas into the stack and supply air through an air preheater, between the convection section and the stack, and to the floor burners and supplemental convection section burners. Additional convection coils are positioned in the hip section between the radiant cells and the convection section. The furnace design has reduced plot space requirements, increased flexibility in heating multiple services, and allows more even heating of the radiant tubes, and easier radiant tube replacement.

ABSTRACT OF THE DISCLOSURE

A twin-cell furnace for process stream preheat and utility steam superheat. The furnace uses a pair of vertical radiant cells with top supported, bottom guided, single row, multiple pass vertical coils fired on opposite sides by floor-mounted burners. An overhead convection section is centered between the radiant cells. Induced and forced draft fans are placed over the convection section to draw combustion gas into the stack and supply air through an air preheater, between the convection section and the stack, and to the floor burners and supplemental convection section burners. Additional convection coils are positioned in the hip section between the radiant cells and the convection section. The furnace design has reduced plot space requirements, increased flexibility in heating multiple services, and allows more even heating of the radiant tubes, and easier radiant tube replacement.

PROCESS FURNACE

FIELD OF THE INVENTION

This invention relates to a furnace useful as a primary source of heat in a plant for preheating process streams and providing a majority of utility steam superheat, and more particularly to a multiple cell vertical tube furnace having different services in each radiant cell and a single convection section with optional supplemental firing located above the radiant cells.

BACKGROUND OF THE INVENTION

Radiant firebox configurations in prior art furnaces produced non-uniform heating of the tubes which led to an increase of the surface area required for radiant heating. Also, some arrangements in prior art furnace designs resulted in a difficult radiant tube replacement. Further, prior art furnaces with multiple services required complex controls or shutdown systems to protect furnace components during all operating conditions. In addition, burner arrangement in prior art furnaces leads to complication combustion air duct configurations which restrict access for operation and maintenance. It would be desirable to be able to provide a furnace design with multiple cell configurations to allow for separate services in each cell, in turn allowing increased flexibility in the firing which facilitates keeping the furnace within its design limits during startups, shutdowns and emergency situations. The use of multiple firing locations would allow for increased flexibility in maintaining process and utility temperatures while allowing for better fuel utilization and efficiency. It would also be desirable to employ a minimum number of combustion air ducts to simplify the design of the combustion air control system.

U.S. Patent 5,500,034 to Martin discloses a process furnace using vertical, U-shaped wicket coils with multiple side burners. Each U-shaped vertical tube has a single pass in the radiant heating section between inlet and outlet manifolds.

U.S. Patent 3,768,980 to Andersen discloses a furnace with catalyst-filed vertical tubes disposed in twin radiant cells with multiple sidewall burners on either side of the tubes. An inlet manifold distributes process fluid to the tube heads from above the chamber roof through inlet pigtails, and straight pipes connect the two bases to a lower outlet manifold. In this single-pass arrangement, the long and bent pigtails are said to have been replaced by short, straight pipes which can still absorb the individual bending of the vertical reactor tubes, and all other stresses are said to have been eliminated through a suspension system attached to the tube bases.

Perry's Chemical Engineer's Handbook, 6th Edition, pages 9-60 through 9-63 (1984) relates the principal classification of fired heaters according to the orientation of the heating coils in the radiant section, that is, whether the coils are vertical or horizontal. Various vertical-tube fired heaters include vertical-cylindrical, all radiant; vertical-cylindrical, helical coil; vertical-cylindrical, with cross-flow-convection section; vertical-cylindrical, with integral-convection section; arbor or wicket type; and vertical-tube, single-row, double-wall fired.

As far as applicants are aware, the prior art does not disclose a process stream preheating furnace using multiple horizontally separated vertical radiant cells with a plurality of top supported, bottom guided, single row, multiple pass, vertical radiant coils fired on opposite sides by floor-mounted vertical upshot burners.

SUMMARY OF THE INVENTION

The present invention provides a multiple cell, vertical furnace having a single convection section with optional supplemental firing, located above and between the radiant cells.

In one aspect, the invention provides a furnace useful as a primary source of heat in a plant for process stream preheat and a majority of utility steam superheat. The furnace includes a plurality of horizontally separated, vertical radiant cells, a convection section located above the radiant cells and receiving combustion gas therefrom. Preferably, an induced draft fan is located above the convection section, and a forced draft fan is located above the convection section. The vertical cells each contain a plurality of top supported, bottom guided, single row, multiple pass, vertical radiant coils fired on opposite sides by floor-mounted vertical upshot burners. The forced draft fan supplies air through an air preheater, preferably located between the convection section and the stack, and then to the burners. The induced draft fan draws combustion gas through the furnace, exhausting into a stack.

In a preferred embodiment, there are two radiant cells in the furnace, and the convection section above the radiant cells is centered between the two cells. The furnace preferably includes a hip section between the radiant cells and the convection section. Supplemental burners can be located beneath the convection section to provide supplemental heat to the convection section.

Ducts can be included for passing combustion air from the forced draft fan to the air preheater, and then to the floor-mounted burners and the supplemental burners.

The radiant coils are preferably top supported and have inlets and outlets at the top of the radiant cells to allow unrestricted downward thermal growth of the radiant coils. The convection section can be foreshortened to increase flue gas velocity in the convection section.

Using the furnace of the present invention, the installed cost is reduced when compared to other designs. Locating the air preheater and the forced and induced draft fans with their drivers in the furnace structure above the convection section, instead of at grade, reduces the plot space requirements of the furnace. The use of the air preheater allows for increased heat recovery, and reduces the fuel consumption. With offset of the radiant coil inlet and outlet manifolds, and use of a foreshortened convection section, the furnace radiant coil replacement is simplified through creation of an unobstructed lane above the upper end of the radiant box.

The double fired radiant coils allow for high average flux rates, reducing the required radiant surface area and providing for a more even heating of the tubes in the radiant section. The double fired design also permits higher process fluid outlet temperatures for a given tube design, in contrast to a single fired design.

Separate services can be provided in each of the radiant cells, with a resulting enhancement of flexibility in the firing which allows the furnace operators to keep the furnace within design limits during startups, shutdowns and other emergency situations.

Multiple firing locations in each radiant cell and in the convection section allow for increased flexibility in maintaining process and utility temperatures while allowing for better fuel utilization and efficiency. A minimum number of combustion air ducts simplifies the design of the combustion control system when compared to some prior art designs.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an end elevation, partially cut away, of a furnace according to the present invention.

Fig. 2 is a side elevation, partially cut away, of the furnace of Fig. 1.

DETAILED DESCRIPTION OF INVENTION

With reference to Figs. 1 and 2, combustion air is supplied to furnace **100** by forced draft fan **102** (see Fig.1) via air preheater **104** and duct **106** to burners **108**. Flue gas passes through the furnace **100** from the burners **108** via radiant cells **110**, **112**, hip section **114**, convection section **116**, air preheater **104**, induced draft fan **118**, and stack **120**.

Radiant cells **110** and **112** are provided on either side of the base of the furnace **100**, preferably spaced horizontally apart from each other (see Fig. 1). If desired, additional radiant cells (not shown) can be provided. Each radiant cell **110**, **112** contains a plurality of single row, multiple pass radiant coils **122** fired on either side thereof by floor mounted burners **108** firing upwards along the sidewalls **124**. The floor **126** is supported over a base which can comprise a plurality of concrete piers **128**.

Each radiant coil **122** consists of multiple serpentine passes located along the centerline of the radiant cells **110**, **112** between the burners **108**. As seen in Fig. 1, the coils **122** are top-supported and are connected to inlet manifolds **130,131** and outlet manifolds **132,133** running horizontally offset from the centerline above each of the radiant cells **110,112**. Variable support springs **134** and penetration boots **136** are used at the top of the arch **138** to support the coils **122**.

A guide pin **140** is attached at the lowermost end of each bend in the coils **122** and extends downwardly into a respective expansion sleeve **142** positioned in the floor **126** along the centerline of the respective radiant cell **110**, **112**. The expansion sleeve **142** is attached to the structural base of the floor **126.** Except for the guide pins **140**, the coils **122** are spaced vertically above the floor **126** to allow for thermal expansion of the coils **122**, while the interengagement of the guide pins **140** and expansion sleeves **142** maintains horizontal alignment of the coils **122** along the centerline. This arrangement of the coil inlets and outlets at the top allows for unrestricted downward thermal growth of the tubes **122**, minimizing the chance of deformation. The design is flexible enough that it is not necessary that each cell **110**, **112** have the same tube size or service as the other.

The sidewalls **124** and floor **126**, as well as the walls of the convection section **116**, hip sections **114**, hot combustion air ducts **106**, stack **120**, and the like, are conventionally lined with insulation materials well known to those in the art, such as, for example, firebrick, silica block, ceramic fiber blanket, castable, etc. The materials are generally selected to meet the temperatures expected during operation of the furnace **100**. The firebrick typically used on the floor **126** can be prefabricated to accommodate the burners **108** and expansion sleeves **142**. The sidewalls **124** can be structurally reinforced with conventional stiffeners (not shown), as well as the convection section **116**, hip sections **114** and ducts **106**. The structure of the furnace **100** can be conventionally reinforced with diagonal bracing (not shown) for wind bracing.

The radiant cells **110**, **112** can include conventional peep sights **144** and access doors **146**. Platforms **148** can be provided at various levels around each cell **110**, **112** with stairs **150** for access to the peep sights **144** and access doors **146**. If desired, the radiant cells **110**, **112** can be installed as a plurality of prefabricated modules which are secured together in place in the structure of the furnace **100**.

The convection section **116** is located on top of and between the two radiant cells **110**, **112**. In order to increase the flue gas velocities and reduce capital cost, the convection section **116** can be foreshortened, meaning that it is horizontally shorter than the radiant boxes **110**, **112**, as best seen in Fig. 2. The convection section **116** is preferably less than 40 feet long, whereas the radiant cells **110**, **112** are preferably greater than 40 feet in length, for example, 38 feet and 50 feet, respectively. The increased flue gas velocity aids heat transfer by increasing the outside heat transfer coefficients for the tubes in the convection section **116**. The foreshortened length of the convection section **116** also leaves open spaces above either end of the radiant cells **110**, **112** to facilitate removal and replacement of the coils **122**. A full length convection section **116** can also be used, since this will work for this design, however, the capital cost will increase some, the heat transfer efficiency may not be as good, and access for radiant tube replacement may be more restricted.

The convection section **116** includes convection coils **116a**, **116b**, **116c**, **116d** which are provided for heating various process and utility streams. For example, coils **116a** and **116b** can be used to superheat high pressure steam, and coils **116c** and **116d**, operating at a lower temperature, to preheat process feed streams prior to heating the radiant cells **110**, **112**. Additional or fewer coils can be employed in the convection section **116**, as desired.

The convection section **116** is preferably installed as one or more prefabricated modules. For example, coils **116a** and **116b** are illustrated in Figs. 1-2 as one module, and coils **116c** and **116d** as another. The modules facilitate construction of the furnace **100**. Each module preferably includes a terminal end **152** and a tube removal end **154**. Generally, fluids to be heated in the coils **116a-d** are supplied and returned at the terminal end **152**, while end **154** is usually accessed only for the purposes of maintenance of the convection section **116** and/or tube service on the convection coils **116a-d**.

Optional burners **156** located directly underneath the vertical convection section **116** provide supplemental firing for maintaining the steam superheat temperature. Optional convection coils **158** can also be installed in the hip section **114** (between the radiant cells **110**, **112** and the vertical convection bank **116**). The coils **158** help to reduce the gas temperature prior to supplemental burners **156**, allowing a more economical design for the coil **116a** in the convection section **116.**

The air preheater **104,** forced draft fan **102**, and induced draft fan **118** are located above the convection section **116** in the furnace structure. The forced draft fan **102** supplies air to the air preheater **104**, and then to the ducts, **106** which supply preheated air to the radiant section burners **108** and the supplemental burners **156** (see Fig. 1). A damper **159** is provided to adjust the volume of air supplied by the forced draft fan **102**. The induced draft fan **118** pulls combustion gas from the convection section **116** and discharges it into the stack **120**. A damper **160** (see Fig. 1) is provided to adjust the volume of flue gas drawn by the induced draft fan **118** and thereby control the operating pressure in the firebox. The ducts **106** are appropriately sized and insulated for the anticipated volume and temperature of combustion air. The combustion air supplied via duct **169** to supplemental burners **156** is controlled by damper **162** (see Fig. 2). The combustion air supplied via ducts **164**, **166** (see Fig. 1) to burners **108** is likewise controlled by dampers **168** (see Fig. 2). The ducts **164**, **166, 169** can be tapered in cross-sectional area from the respective inlet from duct **106** to the opposite terminal end to maintain velocity of the combustion air as it feeds the burners **108, 156**. Fuel is supplied to the burners **108**, supplemental burners **156** and pilot systems (not shown) via conventional fuel header systems (not shown). Conventional fuels supplied to the burners **108, 156** include natural gas, fuel oil, or the like.

The present furnace has particular advantage when used in the front end of a synthesis gas based plant for methanol or ammonia or in a hydrogen plant. In a methanol, hydrogen or synthesis gas plant, one cell would heat a mixture of hydrocarbon and steam and the other cell would heat utility steam. In an ammonia plant, one cell heats a mixture of hydrocarbon and steam and the other cell heats a mixture of steam and air.

Various modifications will be obvious to the skilled artisan in view of the above disclosure of the preffered embodiments. Such modifications which do not depart from the spirit of the invention are intended to be covered by the following claims.

CLAIMS:

1. A furnace useful as a primary source of heat in a plant for process stream preheat and a majority of utility steam superheat comprising:

a plurality of horizontally spaced apart, vertical radiant cells, each having a different service and containing a plurality of top supported, bottom guided, single row, multiple pass vertical radiant coils fired on opposite sides by floor-mounted burners;

a convection section elevated above the adjacent radiant cells and receiving flue gas therefrom;

an induced draft fan for drawing flue gas from the convection section into a stack; and

a forced draft fan for supplying air through an air preheater and then to the burners.

2. The furnace of claim 1 wherein the induced draft fan and the forced draft fan are elevated above the convection section.

3. The furnace of claim 1 wherein the air preheater is located between the convection section and the stack.

4. The furnace of claim 1 further comprising convection coils in a hip section between the radiant cells and the convection section.

5. The furnace of claim 1 further comprising supplemental burners located beneath the convection section for providing supplemental firing of the convection section.

6. The furnace of claim 5 including ducts from the forced draft fan to the air preheater and then to the floor mounted burners and the supplemental burners.

7. The furnace of claim 1 wherein the radiant coils have inlets and outlets at the top of the radiant cells to allow unrestricted downward thermal growth of the radiant coils.

8. The furnace of claim 1 wherein the convection section is foreshortened.

9. The furnace of claim 1 comprising a pair of said radiant cells in a twin-cell configuration wherein the convection section above the radiant cells is centered between the radiant cells.

10. A furnace useful as a primary source of heat in a plant for process stream preheat and a majority of utility steam superheat comprising:

a pair of horizontally spaced apart, vertical radiant cells, each having a separate service and containing a plurality of top supported, bottom guided, single row, multiple pass vertical radiant coils fired on opposite sides by floor-mounted burners, wherein the radiant coils each have an inlet and outlet at the top of the radiant cells to allow unrestricted downward thermal growth of the radiant coils;

a convection section located on top of and centered between the radiant cells to receive combustion gas therefrom;

an induced draft fan elevated above the convection section for drawing combustion gas from the convection section into a stack;

a forced draft fan elevated above the convection section for supplying air through a duct to an air preheater located between the convection section and the stack, and then through ducts to the burners;

convection coils in a hip section between the radiant cells and the convection section.

11. The furnace of claim 10 further comprising supplemental burners located beneath the convection section for providing supplemental firing of the convection section.

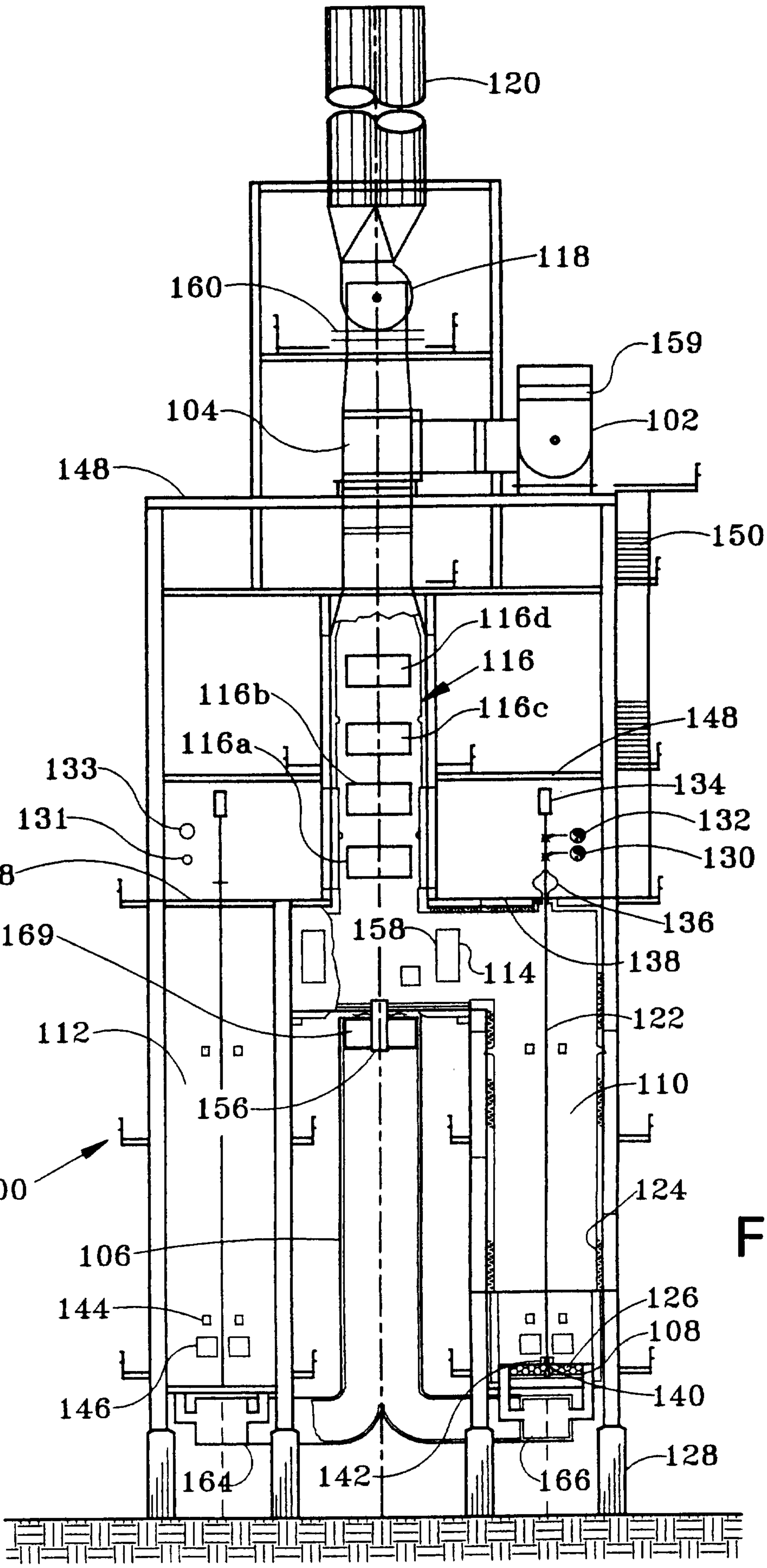
12. The furnace of claim 10 wherein the convection section is foreshortened.

13. The furnace of claim 11 wherein the convection section is foreshortened.

14. The furnace of claim 13 wherein the foreshortening of the convection section creates a lane above the radiant cells for removal of the coils.

15. The furnace of claim 10 installed in a front end of a methanol, hydrogen or synthesis gas plant wherein one of the radiant cells has a hydrocarbon feedstock service and the other radiant cell has a steam superheat service.

16. The furnace of claim 10 installed in a front end of an ammonia plant wherein one of the radiant cells has a mixed hydrocarbon and steam service and the other radiant cell has a mixed steam and air service.


120
118
160
159
104
102
148
150
116d
116
116b
116c
148
116a
133
134
131
132
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148
136
158
169
138
114
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122
110
156
100
124
106
126
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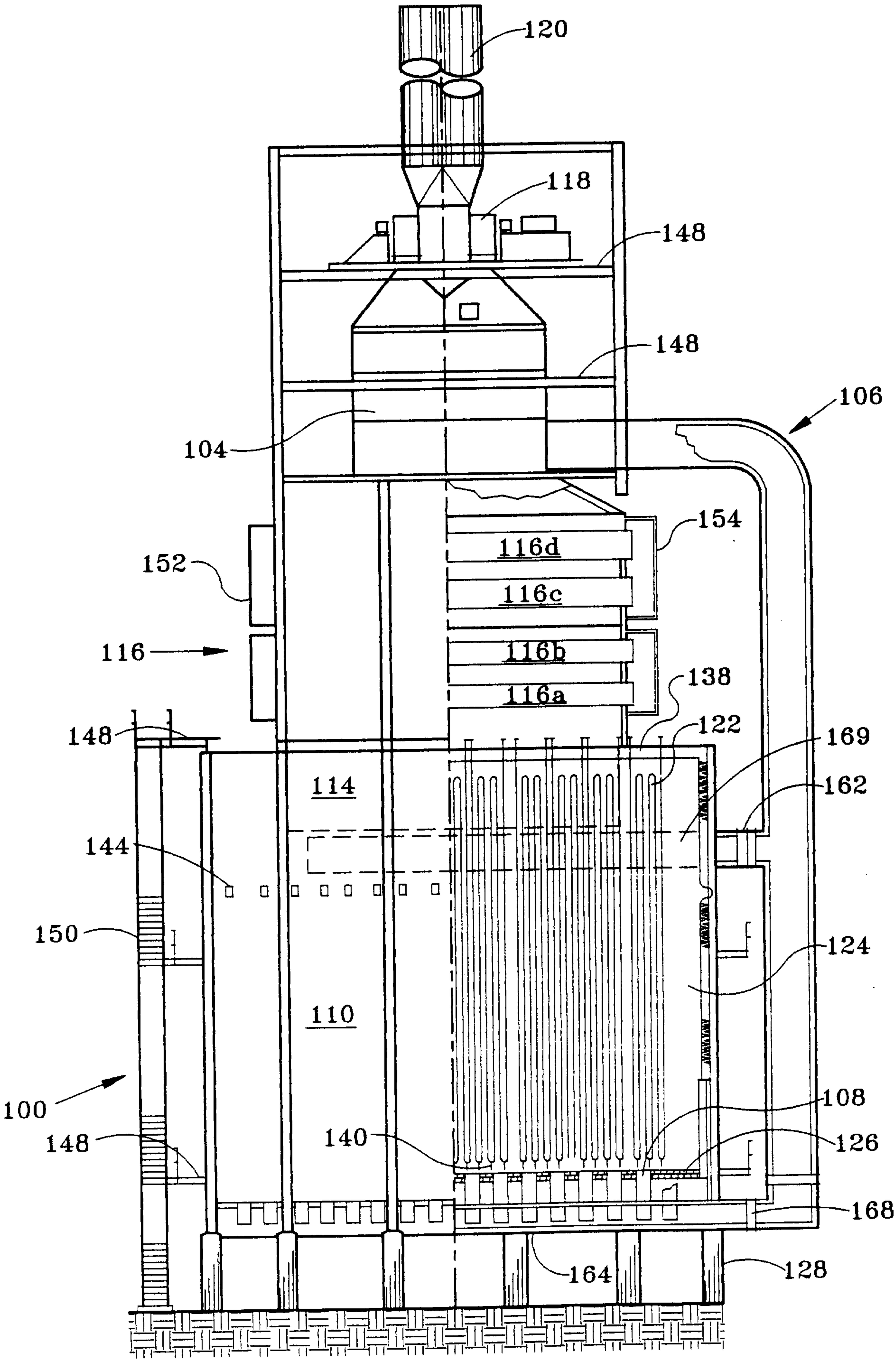
128

FIG.1


120
118
148
148
106
104
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152
116d
116c
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116b
116a
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124
110
100
108
148
140
126
168
164
128

FIG.2