Nov. 5, 1957 P. H. KOCH ET AL 2,811,955

VAPOR GENERATING INSTALLATION WITH MULTIPLE PLATEN RADIANT SUPERHEATER

Filed Dec. 6, 1950 4 Sheets-Sheet 1

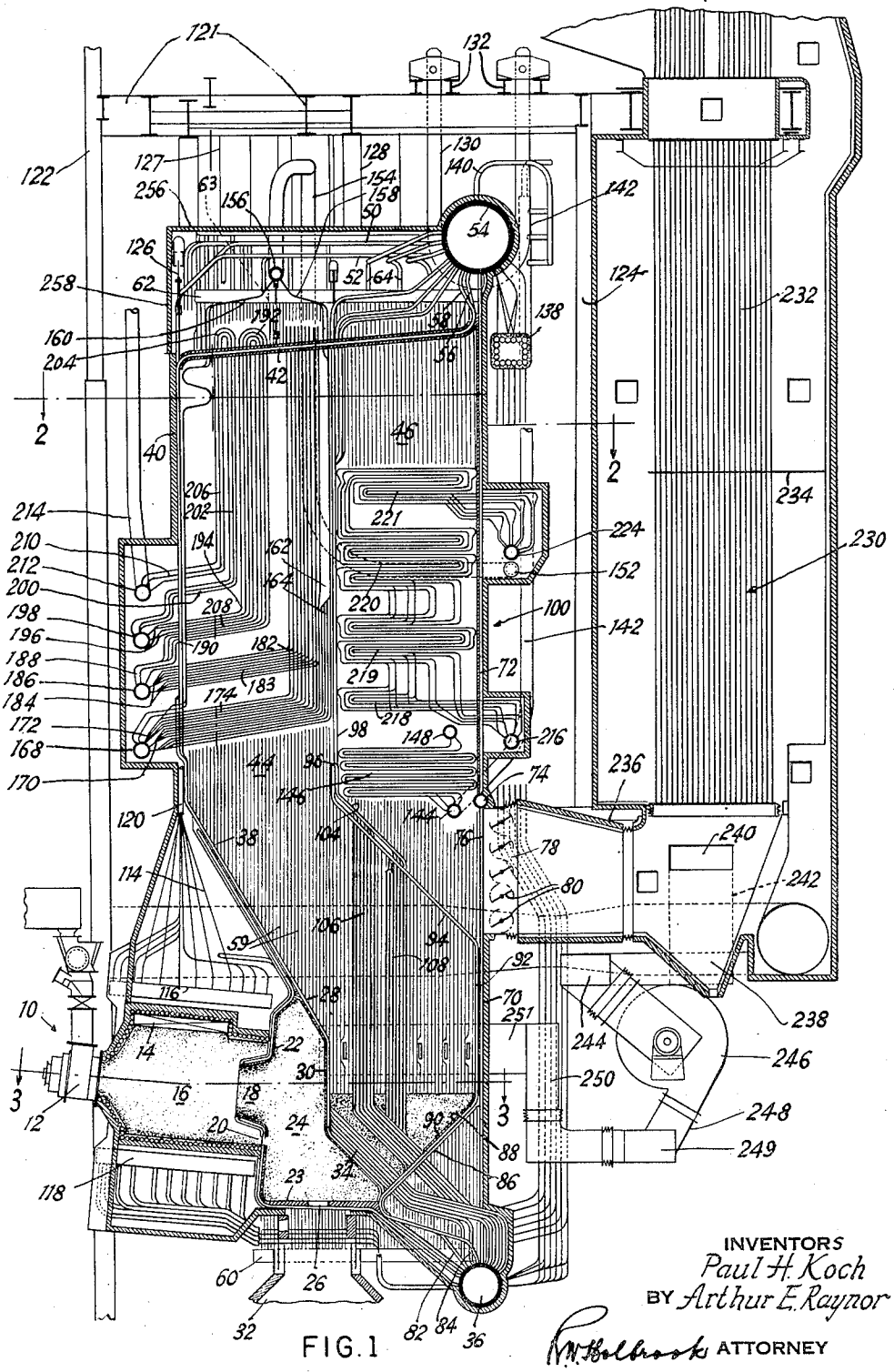


FIG. 1

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Filed Dec. 6, 1950 4 Sheets-Sheet 2

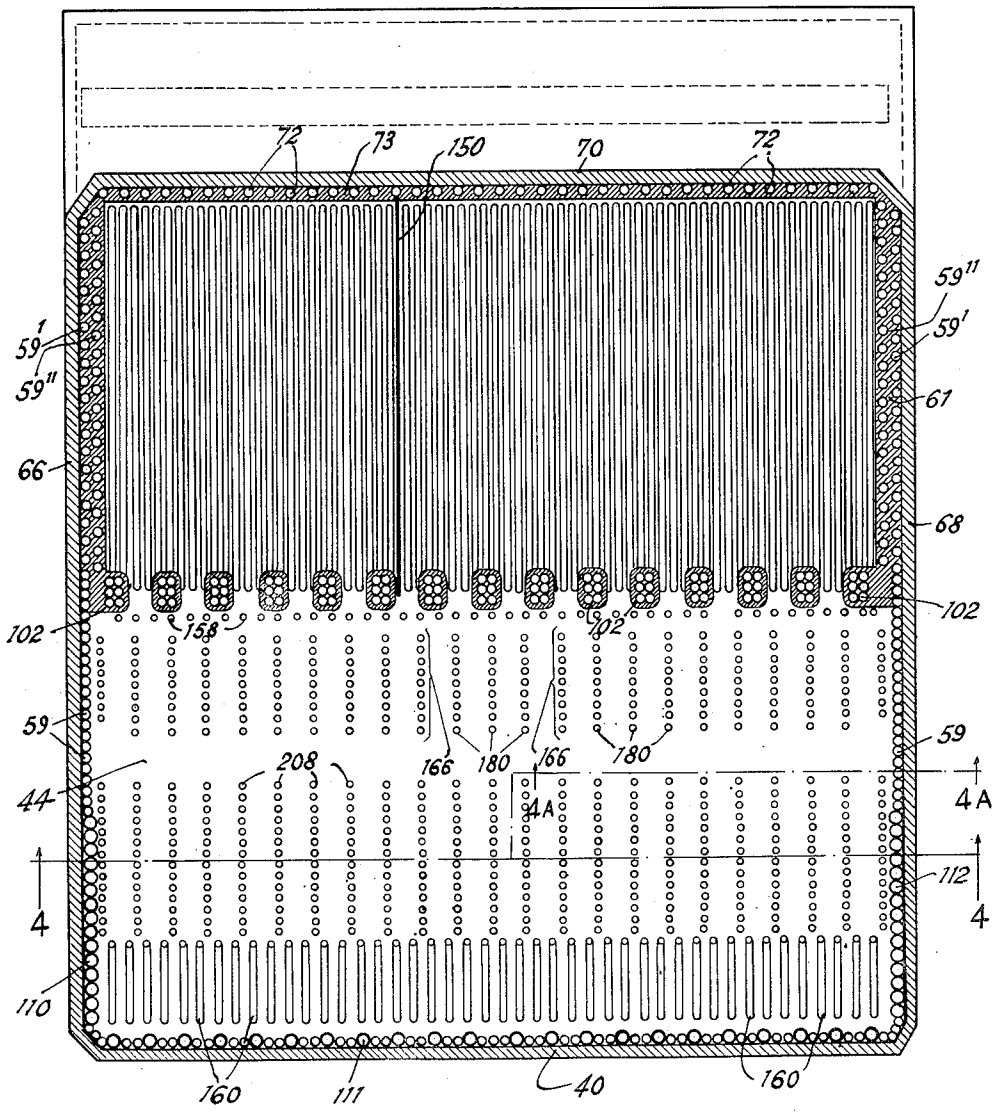
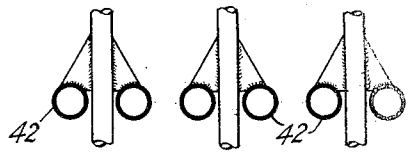


FIG. 2

FIG. 5



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VAPOR GENERATING INSTALLATION WITH MULTIPLE PLATEN RADIANT SUPERHEATER

Filed Dec. 6, 1950 4 Sheets-Sheet 3

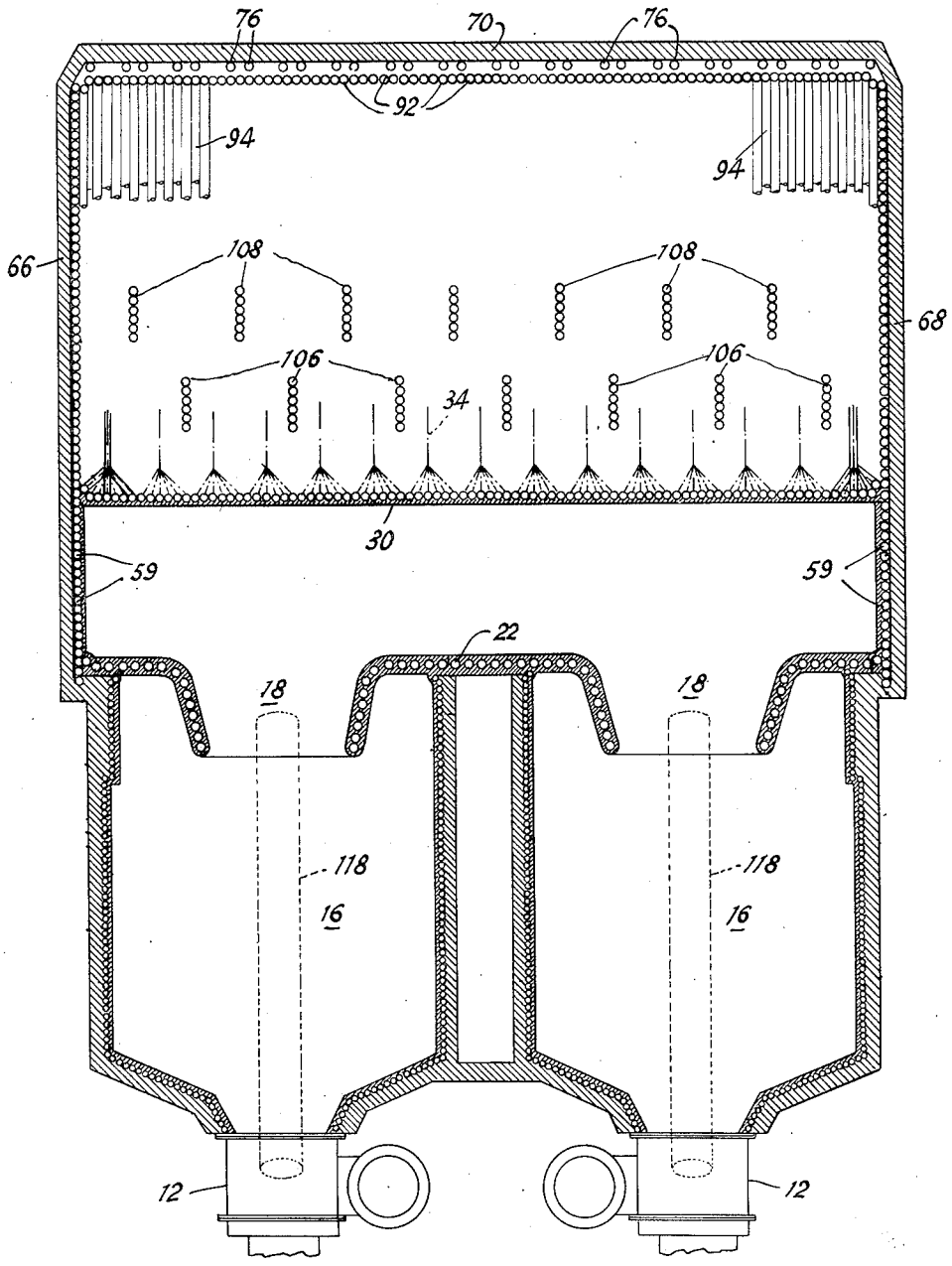


FIG. 3

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VAPOR GENERATING INSTALLATION WITH MULTIPLE PLATEN RADIANT SUPERHEATER

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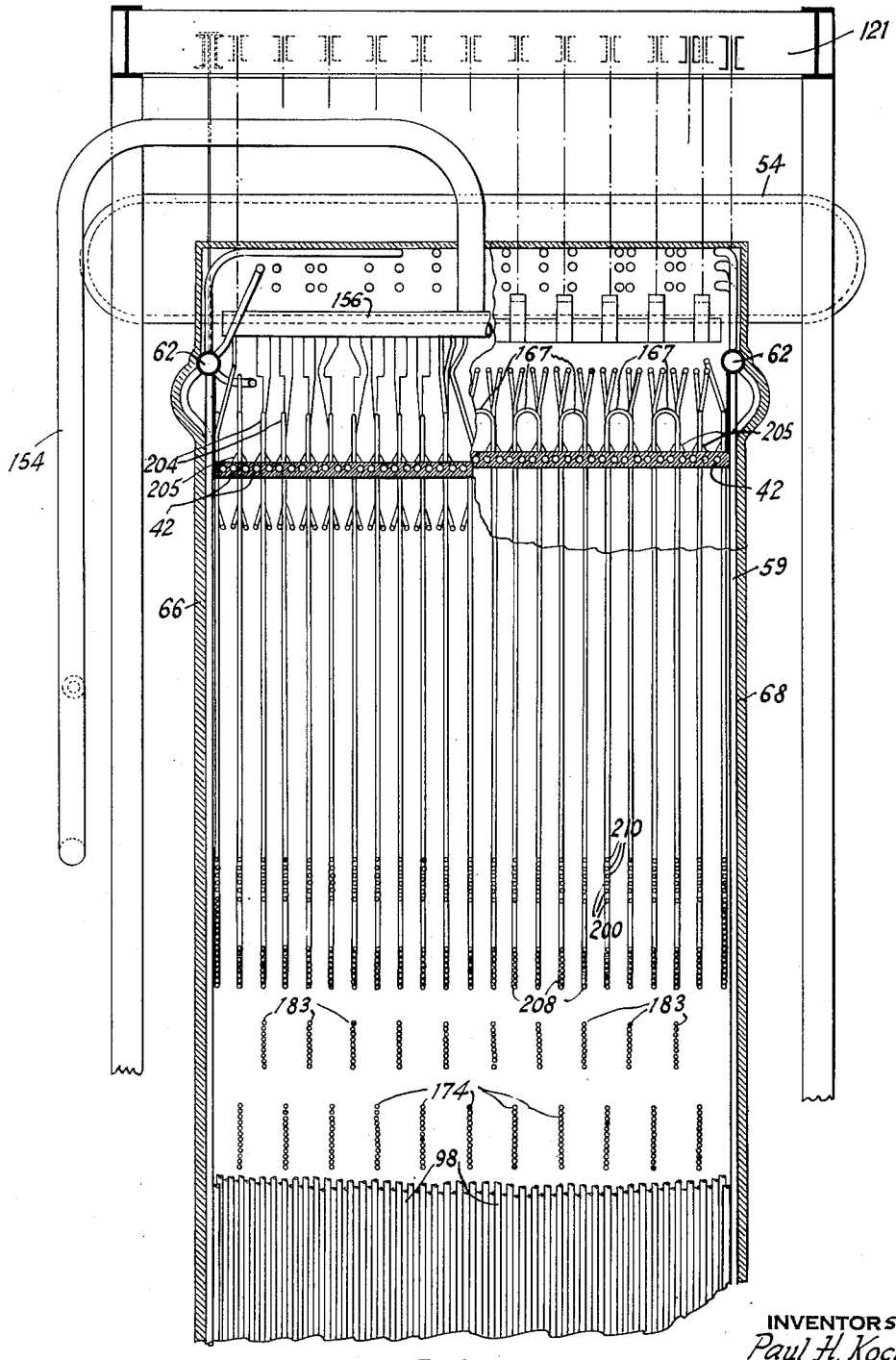


FIG. 4

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2,811,955

VAPOR GENERATING INSTALLATION WITH MULTIPLE PLATEN RADIANT SUPERHEATER

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Application December 6, 1950, Serial No. 199,480

9 Claims. (Cl. 122—479)

This invention relates to steam generating and superheating installations, and it is more particularly concerned with such installations in which steam is generated and superheated at high temperatures and pressures in tubes exposed to heat of a furnace burning a slag forming fuel and operating at high gas temperatures.

More particularly the invention is concerned with steam generating and superheating installations such as above indicated, fired by the burning of a granular slag forming fuel such as coal, in a cyclone furnace, and having platens of radiant superheater tubes exposed directly to furnace gases in a part of a secondary furnace chamber receiving products of combustion from the cyclone furnace.

In the rapid progress of modern steam generation and steam superheating, greater and greater efficiencies have been attained by operation at higher and higher temperatures and pressures, and with this attainment of increasingly higher efficiencies, increasingly greater portions of the total heat released has been absorbed by the installation components other than the furnace. Such components include the steam superheater and reheater. With the concomitant decrease of total heat absorbed by the furnace of such installations, the products of combustion passing from the furnace have attained increasingly higher temperatures, and with the insistant demand for higher efficiencies higher gas temperatures have been necessary to attain the desired final steam temperatures. These temperatures have been within the range in which slag particles are carried with the gas into the superheating zone, in installations burning slag forming fuels. This condition, and the important consideration of minimizing draft losses have created a demand for an optimum superheater which would attain the higher final steam temperature with a minimum of slagging and with a minimum draft loss.

This invention meets the indicated demands by providing a superheater including radiant tube platens directly exposed to the high temperature combustion products within a high temperature furnace chamber. The tubes are arranged in platens extending generally in the direction of gas flow and are constructed and disposed in the furnace so as to minimize the difficulties resulting from the expansion and contraction of the tubes, considering the high temperatures of their normal operation.

The superheater tube platens of the invention are so constructed and arranged as to provide the necessary superheat capacity without incurring the difficulties which would result if attempts were made to attain such capacity by using wall tube radiant superheaters or similar furnace boundary superheaters in which the tubes are disposed along such boundaries. With the radiant superheater of the present invention, the size of the furnace is reduced, as compared to a furnace which would be necessary if all of the radiant superheater capacity were attained by the use of wall tubes, or furnace boundary radiant superheaters. Furthermore, the radiant superheater of the present invention is so constructed and arranged that it does not involve any such maintenance difficulties as those involved in maintaining the furnace boundary integrity of a wall tube or furnace boundary radiant superheater. The superheater platens of the present invention are so arranged, constructed, and maintained that the expansion and contraction of the superheater tubes do not materially change their operative arrangement.

In the specific construction covered by the present invention, the radiant superheater tubes are arranged with a plurality of platens at the top of a high temperature furnace chamber with the tubes of the platens extending upwardly from headers at one side of the chamber. The tubes extend at an upward inclination across the chamber and then vertically upward in platen formation to positions in front of the gas outlet of the furnace chamber. This arrangement with the headers mounted at the lower ends of the tubes of the various superheater platens, provides a superheater which is readily drainable so as to eliminate difficulties which might otherwise be caused in the starting up of the installation.

The invention is described herein with reference to an illustrative installation shown in the accompanying drawings.

In the drawings:

Fig. 1 is a vertical section through the illustrative installation;

Fig. 2 is a horizontal section on the section line 2—2 of Fig. 1, looking in the direction of the arrows;

Fig. 3 is a horizontal section on the line 3—3 of Fig. 1;

Fig. 4 is a vertical section generally on the line 4—4 of Fig. 2, but with a part broken away to show a partial section on the line 4A—4A of Fig. 2; and

Fig. 5 is a fragmentary elevation showing the manner of supporting the superheater tubes upon the roof tubes.

The drawings indicate a high capacity steam generating and superheating installation operating at a steam pressure of the order of 875 p. s. i., and at a capacity of 575,000 lbs. per hour. The installation involves a steam superheater and reheater each delivering steam at 1000° F.

The illustrative installation involves fuel burning means including a cyclone furnace generally indicated at **10** in Fig. 1. This furnace is characterized by high combustion efficiency and a recovery of a high percentage (90–95%) of the recoverable portion of the fuel ash in the formation of molten slag. The cyclone furnace and its associated components are constructed and arranged in a manner similar to that indicated in the U. S. patent to Bailey et al. 2,357,301, September 5, 1944. In the operation of the furnace, crushed coal and a supply of preheated primary air under superatmospheric pressure are delivered tangentially to the cyclone furnace at the inlet **12**. This introduction of primary air and coal to the furnace takes place at a velocity high enough to cause the coal particles to be thrown toward the cylindrical wall of the cyclone which is formed by fluid cooled studded tubes covered on their inner sides by high temperature refractory material. High temperature secondary air is admitted to the cyclone through the inlet **14** in a path generally parallel to the path of movement of the air and primary coal. The temperature of the products of combustion in the cyclone furnace is high enough to melt the ash into liquid slag which clings to the wall of the furnace. The particles of incoming coal are trapped in this surface layer of molten ash, and the scrubbing action of the high velocity of combustion air over these coal particles results in effective combustion at high fuel burning rates.

The combustion gases with slag particles therein exit from each primary cyclone furnace chamber **16** through its outlet **18** in a turbulent condition, and slag formed and accumulated in this cyclone chamber **16** passes

through the slag opening 20 formed by outward bends in some of the fluid cooled tubes defining the rear wall 22 of the primary chamber of the cyclone. Slag flowing through the opening 20 drops to a slag collecting bottom 23 of the secondary cyclone chamber 24, from which it passes through an opening 26 and drops into a body of water within the slag pit or tank 32.

The upper and rearward wall of the secondary chamber of the cyclone furnace is defined by steam generating tubes 28 connected into the fluid circulation system of the installation. Parts of these tubes, with their covering of refractory on their furnace sides form the reflecting arch 30. Below this arch, the steam generating tubes are bent to form the transversely placed platens of a slag screen 34, disposed at an angle of approximately 45° to the horizontal as indicated in the drawings. These platen forming tubes extend downwardly and have their lower ends directly connected to the submerged lower drum 36. Above the reflecting arch 30, these tubes extend vertically from the top of the inclined boundary surface 38. They extend along the furnace chamber wall 40 to positions near the top of the installation. Some of these tubes have roof sections 42 associated with heat resistant material to form the roof of the radiant heat absorption furnace chamber 44 and the downward gas pass 46. Others of the tubes disposed along the wall 40 extend above the roof of the furnace chamber 44, and then horizontally through their circulator sections 50 and 52 to direct connections with the steam and water separating drum 54. The roof tubes similarly have their upper ends 56 and 58 directly connected with the steam and water mixture space of the drum 54.

Gaseous combustion products with their suspended ash particles flow from the secondary chamber of the cyclone furnace through an outlet beneath the reflecting arch 30, and between the tube platens 34 into the lower part of the furnace chamber 44. They pass upwardly through the latter and between widely spaced platens of contiguous radiant superheater tubes distributed across the furnace chamber 44. They then turn to the right and flow horizontally into the equalizing chamber at the top of the downpass 46 and over the components of tubes constituting a reheater and a primary superheater disposed in the gas pass.

The remaining walls of the furnace chamber 44 are defined by steam generating tubes having their lower ends appropriately connected to the submerged drum 36, and their upper ends connected to the steam and water drum 54. The side walls are defined by steam generating tubes 59 (Fig. 2) directly connected at their lower ends to transverse headers, such as the header 60 at the lower part of Fig. 1, this header being appropriately in communication with the submerged drum 36 by suitable tubular connectors. The upper ends of the side wall tubes are connected with the horizontally disposed and diaphragmed headers such as 62 directly to the drum 54 by circulators 64.

At the upper part of the installation, as shown in Fig. 2, the upper parts of some of the tubes 59 are arranged in two rows so that they may be covered with the intervening refractory material 61 to reduce heat absorption by the tubes and thereby maintain high temperatures of the furnace gases at the positions of the reheater 100 and the primary superheater. In Fig. 2 the two rows of upper parts of these tubes 59 are indicated at 59' and 59''.

The installation is generally rectangular in horizontal section as indicated in Fig. 2, having the front wall 40, the side walls 66 and 68, and the rear wall 70. The latter includes steam generating wall tubes 72 connecting the intermediate transverse header 74 directly to the drum 54. Above this header the tubes 72 are covered with refractory material 73 to further promote high gas temperatures. Immediately beneath the header 74 the wall tubes 76 extend in spaced relationship across the gas outlet 78 of the downpass 46. The flow of gas through the reheater part of this outlet is controlled by a plurality of

dampers 80. The tubes 76 extend downwardly below the gas outlet 78, and along the wall 70 to direct connection with the drum 36. The wall 70 includes the heat insulating material disposed externally of the tubes 76 as well as the refractory material 73 disposed on the gas sides of the tubes 72.

Other steam generating tubes have their lower ends 82 and 84 directly connected to the drum 36, and their inclined sections 86 and 88 associated with their refractory material 90 to form an inclined wall extending downwardly toward the floor 23 of the secondary chamber of the cyclone furnace. Above this inclined section, these tubes have the upright portions 92 extending along the lower part of the wall 70. Next above these are the inclined sections 94 associated with other tube sections and refractory material to form an inclined base for the downward gas pass 46. Beyond this base these tubes are joined by bifurcations 96 to upright portions 98 disposed along the division wall dividing the upper part of the furnace chamber 44 from the downward gas pass 46. The bifurcations 96 might also be regarded as Y-connections with each of the tubes 98 being joined by such a Y-connection with two of the tubes such as 104 and 94. Above the level of the reheater, generally indicated at 100, these tubes are parts of the refractory covered groups of tubes 102 spaced across the gas flow from the top of the furnace chamber 44 to the top of the gas pass 46. These refractory covered groups of tubes 102 are constructed and arranged so as to minimize heat absorption by the tubes at the outlet of the furnace chamber 44. This promotes higher furnace gas temperatures at the positions wherein the furnace gases turn downwardly at the top of the downflow gas pass and contact the banks of tubes of the reheater and the primary superheater. The other tubes in these groups 102 lead from bifurcations similar to 96. The upper legs 104 of these bifurcations continue downwardly through the tubes of the platens 106 and 108 which extend vertically through the lower part of the furnace chamber 44. At the lower ends of these platens, the component tubes extend through the inclined wall including tube sections 86 and 88 to direct connection with the drum 36 as clearly indicated in the drawing.

The front wall 40 of the furnace chamber 44 and the forward portions of its side walls 66 and 68 include large diameter risers such as 110, 111, and 112 of the wall cooling system for the cyclone furnace. These large diameter risers are connected to the left portions of side wall headers 62, these portions being separated from the remainders of the headers by diaphragms 63. Some of these risers, as indicated by the numeral 120 in Fig. 1, have sections such as 114 extending upwardly from an upper cyclone header 116 which is fed by substantially semi-circular tubes extending around the cyclone to a lower header 118, the latter being in communication by tubular connectors with the drum 36. All of the above indicated risers, steam generating tubes or wall tubes are pendently supported from horizontally disposed steelwork such as 121 which is, in turn, supported by columns 122 and 124. Some of the pendent supports from the steelwork to the tubes are connected with headers as indicated at 126—128. Many of the tubes are directly supported from the drum 54 which has the pendent supports 130 secured upon elements 132 of the steelwork.

The fluid circulation system of the illustrative installation includes a series of downcomers having their lower ends directly connected to the drum 36 and their upper ends directly connected to the water space of the drum 54. These downcomers are disposed and secured in hollow square arrangement such as indicated at 138 in the upper part of Fig. 1, covered by heat insulating material.

Steam flows from the steam space of the drum 54 through tubular connectors 140 to the upright conduit 142 and through that conduit to the inlet header 144 of the primary superheater including the bank of return

bend and series connected tubes **146**. From these tubes it flows into the intermediate header **148** and thence upwardly through other banks of return bend tubes which are formed in a manner similar to those of the reheater **100**, the reheater and the superheater, above the bank of tubes **146**, being separated by metallic division wall **150**. From the outlet header **152** of the primary superheater steam flows through a conduit **154** to the inlet header **156** of the secondary superheater which includes a plurality of upright platens formed by series connected tubes and distributed on relatively wide spacings across the gas flow in the upper part of the furnace chamber **44**. Water spray heads are associated with a part of the conduit **154** to constitute an attemperator. From the header **156**, the steam flows through downwardly diverging rows of tubes **158** and **160**. Tubes **158** extend downwardly through the roof of the furnace chamber **44**, and thence across the gas outlet of the furnace chamber **44** and then along the wall dividing the upper part of that furnace chamber from the downflow gas pass **46**. At the position **162** intermediate the height of this wall, the tubes **158** are fanned out to upright platen formation, forming parts **164** of superheater platens. These are the rearward parts of platens **166** which are indicated in Fig. 2. At the lower end of these parts of the upright platen tubes, these tubes are bent to the left as indicated in Fig. 1, and form the lower parts of inclined platens having their lower ends directly connected to the header **168**. This header has the lower ends of the superheater tubes **160** also connected thereto.

The superheater inlet tubes **158** enter the header **168** at the lowermost right hand position. With respect to the other tubes connected to that header, the superheater inlet tubes **160** enter the header **168** at a position to the extreme left. Steam flows out of the header **168** through two groups of tubes the lower ends of which are indicated at **170** and **172**. These tubes fan out into platen formations where they cross between the steam generating tubes disposed along the wall **40**. It will be understood that there are several groups of these tubes along the length of the header **168**, and each pair of groups constitutes at least a part of a platen of tubes extending at a horizontal inclination and in platen formation as indicated at **174** in Fig. 1. They continue toward the other side of the furnace chamber **44** and then bend upwardly in platen formation to constitute such platens as those indicated at **166** in Fig. 2. This figure shows a series of parallel platens disposed across the furnace chamber **44**. Every other platen is formed by the vertical continuations of the tubes just described. The tubes of these platens **166** extend upwardly between the roof tubes **42** of the installation. Above the roof they have U-bends **167** (Fig. 4) and they return in platen formation between adjacent pairs of roof tubes to form platens such as those indicated at **180** in Fig. 2, the latter being alternately disposed with reference to the platens **166**. The steam then flows downwardly through the tubes of these platens to a position such as that indicated at **182**, Fig. 1. At this position the tubes of the platens **180** are bent to the left to form the horizontally inclined platens **183** extending across the furnace chamber **44** and then between wall tubes along the wall **40**, and thence to positions **184** of connection to the intermediate secondary superheater header **186**. From this header steam flows through groups of tubes **188** which are fanned out in platen formation where they pass between wall tubes along the wall **40** at the position **190**. From this position, and toward the right, these tubes form parts of horizontally inclined platens **208**. At the right hand end of these horizontally inclined parts, the tubes are bent to extend vertically through the roof of the furnace chamber **44**, above which the tubes have return bends **192**. From these return bends the tubes continue downwardly in platen alignment with adjacent upflow tubes to the position **194** at which they are bent to the left to continue in horizontally inclined platen formation through wall tubes along the walls **40** and to points of connection **196** with the header **198**. The upright platen parts formed by the tubes just described are augmented by other tubes **200**, extending from the header **198** between the wall tubes and to a position of platen alignment with the tubes conducting the upflow steam from the header **186** to those conducting the downflow of steam to the header **198**. The upright parts of the tubes **200** are indicated at **202**. They extend through the roof of the installation above which they have return bends **204**. From these return bends, the tubes continue downwardly through the roof and have vertical portions **206** in vertical alignment with the adjoining tubes to complete the platens indicated at **208** in Fig. 2. These are uniformly distributed across the width of the upper part of the furnace chamber **44** as clearly indicated in the drawings. Steam flows from the last mentioned tubes **206** through their horizontally inclined parts **210** between adjacent wall tubes along wall **40** to points of connection with the header **212**. The flow continues from this header through the conduit **214** to a point of use.

In the illustrative installation, the steam flows from the conduit **214** to a multiple stage turbine installation from a part of which the expanded steam flows at lower pressure and lower temperature into the inlet header **216** of the reheater, or reheat superheater. From this header, the steam flows through banks of tubes **218—221** of series connected return bend tubes vertically and horizontally spaced and disposed across the downward flow of gases in the downpass **46**. From the tubes of the last of these banks of tubes, **221**, steam flows into the outlet header **224** and thence to a succeeding component of the turbine installation.

The drawings further disclose an air heater **230** including a bank **232** of horizontally spaced vertically disposed tubes extending through an intermediate baffle **234**, and arranged for the upward flow of furnace gases therethrough from the dampered gas outlet **78** at the lower end of the downflow gas pass **46**. Air to be heated flows externally and recurrently transversely of these tubes and thence through appropriate ductwork to the air inlets of the cyclone furnace **16**.

The structure near the base of the air heater includes the breeching **236** and the dust hopper **238** which unite to form an enclosed passage for the furnace gases from the lower part of the gas pass **46** to the inlets of the air heater tubes **232**.

For the purpose of controlling the superheat, particularly of a wide load range, the illustrative installation includes a recirculated gas system including means for recirculating a portion of the furnace gases from the recirculated gas inlet **240**, just below the air heater, through the external duct **242** to the ductwork **244** leading to the inlet of the fan **246**. The gas discharge of this fan is connected to ductwork **248—251** communicating the lower part of the furnace chamber **44** along one or both of the side walls of the installation. The amount of recirculated gas is preferably controlled automatically in response to one or more variables such as final superheat temperature, steam flow, and firing rate of the fuel burning means, to effect a uniform optimum degree of superheat over a wide load range, extending from a value near full load to a fraction thereof. The illustration of superheat by control of the rate of flue gas recirculation to maintain a predetermined superheat over a wide load range, is affected by the readjustment between the flow of furnace gases over the superheater and the reheater in their different portions of the downflow pass **46**. This readjustment is effected by control of the dampers positioned at the lower end, or outlet, of that part of the downflow pass containing the reheater **100**.

For heat insulation purposes, the headers, circulators, and parts of their steam generating and steam conducting tubes disposed above the roof of the installation are disposed within an enclosure including a superposed cover **256**, a front wall **258**, and corresponding side walls. The

rear wall of this enclosure is formed by the upper extension of the wall **72**.

To obtain the optimum high degree of superheat by the illustrative installation, the superheater platens are disposed in a gas zone which has a temperature higher than the slagging temperature of the fuel, and these platens are disposed at a wide spacing to inhibit any slag bridging. In this respect it is to be noted that the groups of platens **174** and **183** are on wide spacings, with their spacing about double the spacing of the superposed groups of platens **208** and **210**. Also, the lowermost tubes of the platens **174** are formed by parts of the tubes **158** extending downwardly from the inlet header **156** of the secondary superheater. Therefore, these lowermost tubes of the platens **174** are conducting steam at a temperature lower than the temperature of the steam in the tubes of the superposed platens, and at a temperature lower than the temperature in the remaining parts of the platens **174**. Both of these conditions, as to spacing the tubes and as to the temperature of the fluid within the tubes, promote cooling of the gases and their suspended solids to temperatures at which the latter will not exist in such sticky condition as will cause them to stick to the tubes and accumulate thereon. After the temperature of the gases is lowered by widely spaced platens **174** and **183**, the gases contact the platens **208** and **210** which are arranged with narrower spacing, about one-half the spacing of the lowermost sets of platens. The spaced platens of the installation effect a high rate of heat absorption. Ninety percent or more of the total heat absorbed is transmitted by radiation and the remainder by convection.

The platens permit a greater area of heat absorbing surface than could be economically arranged as a radiant superheater consisting of furnace wall tubes or other furnace boundary surface tubes. Furthermore, the exposure of the tubes of the secondary superheater to uniform heat effects on all sides of the tubes results in the most effective use of the expensive steel alloys required in superheaters for attaining the high temperatures involvd. By the applications of heat to all sides of the superheater tubes, the temperatures throughout the peripheries of the tubes are substantially the same, and metal stresses due to temperature differentials in the tubes are thereby minimized.

Furthermore, the "dog leg" arrangement of the tubes forming the platens of the superheater permits effective support at the upper ends of the platens. It also permits draining of the superheater to the lower end junction header outside of the furnace wall tubes. This arrangement also eliminates substantial metal stresses which would occur in other arrangements. This is accomplished by the angular arrangement of the individual superheater tubes with the intermediate or "dog leg" parts being relatively free to move as a result of temperature changes without imposing substantial stresses upon the supports for the tubes.

Among the characteristics of the illustrative installation is the fact that there is no bank of convection heated tubes in front of the platens of tubes of the secondary superheater. The latter are disposed in a zone which, in may cases, would be otherwise a part of the furnace. This part of the furnace, or furnace chamber, is not a combustion chamber, because the combustion is complete before the zone of the superheater platens is reached. The zone of these platens is, however, a zone in which ash particles are in a plastic condition as a result of the high temperatures.

It is to be understood that terms and expressions used herein are used by way of example, and not of limitation. The installation is shown and described as a steam generating and steam superheating installation, but in this case the term steam is to be taken as an example of an elastic fluid capable of the same generation and treatment for power or other industrial uses. Where the term "water" is used, it is to be taken as an example of a vaporizable fluid.

Similarly, the cyclone furnace is to be taken as an example of a fuel burner or fuel burning means firing the installation at temperatures above the fusion temperature of the ash content of the fuel.

What is claimed is:

1. In an installation for generating and superheating high pressure steam for power purposes, a vertically elongated large volume furnace chamber having its walls defined by steam generating tubes, a steam and water separating drum having communication with the upper ends of said steam generating tubes, fuel burning means disposed at the lower end of said furnace chamber utilizing an ash bearing fuel to fire the furnace chamber at temperatures above the fusion temperature of the non-combustible of the fuel, a convection section receiving furnace gases through a gas outlet at the upper part of the furnace chamber, platens of contiguous superheater tubes disposed at the upper portion of the furnace chamber with the tube platens distributed on relatively wide centers across the chamber, said platens extending generally in the direction of gas flow, the superheater tubes including upright portions extending downwardly from the roof of the furnace chamber and integrally inclined portions extending from the lower ends of the upright portions through a wall of the furnace chamber, means for pendently supporting the superheater tubes at positions adjacent the roof of the furnace chamber, and superheater headers connected to the lower ends of the superheater tubes so that the latter may be drainable.

2. In a vapor generating and superheating installation, a large volume furnace chamber having it walls defined by fluid conducting tubes normally absorbing heat radiantly transmitted from furnace gases with ash particles suspended therein, a fuel burner adjacent one extremity of the said furnace chamber, said fuel burner means being fired with a slag forming fuel and effecting temperatures in the furnace chamber above the fusion temperatures of the ash, said fuel burning also effecting the suspension of fused slag particles in the combustion gases, the gas heated convection section having furnace gas communication with said furnace chamber, and a series of tube platens distributed throughout the gas flow in a part of the furnace chamber between the fuel burning means and the furnace chamber gas outlet, said platens being formed by rows of contiguous tubes with the rows extending generally in the direction of gas flow and having steam connections whereby said platens constitute a vapor superheater heated predominantly by radiation from both the furnace chamber and the gases, the platens being arranged at successively greater spacings from the fuel burning means and with the platen spacing decreasing and the spacing between the adjacent tubes of individual platens increasing as the spacing of the platens from the fuel burning means increases.

3. In an installation for generating and superheating a high pressure elastic fluid for power purposes, a vertically elongated large volume furnace chamber having its walls defined by elastic fluid generating tubes, a liquid and elastic fluid separating drum having communication with the upper ends of said elastic fluid generating tubes, a cyclone furnace disposed at the lower end of said furnace chamber utilizing a granular fuel to fire the furnace chamber at temperatures above the fusion temperature of the non-combustible of the fuel, a convection section receiving furnace gases through a gas outlet at the upper part of the furnace chamber, platens of contiguous superheater tubes disposed at the upper portion of the furnace chamber with the tube platens distributed on relatively wide centers across the chamber, said platens extending generally in the direction of gas flow, the superheater tubes including upright portions extending downwardly from the roof of the furnace chamber and integrally inclined portions extending from the lower ends of the up-

right portions through a wall of the furnace chamber, means for pendently supporting the superheater tubes at positions adjacent the roof of the furnace chamber, and superheater headers connected to the lower ends of the superheater tubes so that the latter may be drainable.

4. In a steam generating and superheating installation, steam generating tubes defining boundary surfaces of a large volume furnace chamber, fuel burning means disposed adjacent an extremity of the furnace chamber and normally burning an ash bearing fuel under conditions effecting furnace gas temperatures higher than the fusion temperature of the ash particles in the furnace gases, a steam superheater consisting of platens of tubes distributed in uniform spacing across a portion of the furnace subject to direct radiant heat from the fuel burning means and receiving heat predominantly by radiation from the furnace gases and the suspended particles therein, each of said superheater tube platens being formed by contiguous and serially connected steam conducting tubes arranged in rows extending generally in the direction of gas flow within the furnace chamber, means pendently supporting the platens of superheater tubes within the furnace chamber, and a convection section subject to the flow of furnace gases beyond the superheater, the platens being so disposed that each has a first part much nearer the fuel burning means than its remaining part, each said first part having its component tubes arranged with center-to-center spacing much less than said remaining part.

5. In a vapor generating and superheating unit, a vertically elongated large volume furnace chamber having its walls defined by vapor generating tubes, a vapor and liquid separating drum having communication with the upper ends of said vapor generating tubes, fuel burning means disposed at the lower end of said furnace chamber utilizing an ash-bearing fuel to fire the furnace chamber at temperatures above the fusion temperature of the ash, a convection section receiving furnace gases through a gas outlet at the upper part of the furnace chamber, platens of tangent superheater tubes disposed in vertically successive rows at the upper portion of the furnace chamber with the tube platens distributed on relatively wide centers across gas flow in the chamber, said platens being disposed edgewise to on-coming gas flow, the superheater further including upright tubular portions extending downwardly from the roof of the furnace chamber to the integral portions forming the platens extending from the lower ends of the upright portions through a wall of the furnace chamber, means for pendently supporting the superheater tubes at positions adjacent the roof of the furnace chamber, superheater headers connected to the lower ends of the superheater tubes so that the latter may be drainable, the superheater headers being disposed exteriorly of a wall of the furnace chamber and so associated with the vertically successive rows of platens that the platens nearest the fuel burning means conduct vapor of the lowest temperature.

6. In a vapor generating and superheating unit, a vertically elongated large volume furnace chamber having a lateral gas outlet at its upper end, vapor generating tubes defining the walls and roof of the furnace chamber, coal burning means connected with the furnace chamber at its lower part so as to supply the furnace chamber with combustion products including high temperature combustion gases with previously fused slag particles suspended therein, the temperature of the combustion gases being greater than the fusion temperature of the slag or ash of the coal, and a multiple platen tubular radiant superheater disposed at the upper part of the furnace chamber and bounding a large volume combustion gas space in the lower part of the furnace chamber, the platens being disposed in groups at positions successively more remote from the position of entry of combustion products into the furnace chamber with the superheater platens nearest said space being widely spaced across the furnace chamber,

each of the superheater platens forming a flat structure including a multiplicity of parallel superheater tubes, said superheater tubes having vertically extending parts extending through the roof of the furnace chamber, and means whereby vapor generated in the furnace chamber wall tubes is conducted to the inlet of the superheater.

7. In a vapor generating and superheating unit, a vertically elongated large volume furnace chamber having a lateral gas outlet at its upper end, vapor generating tubes defining the walls and roof of the furnace chamber, coal burning means connected with the furnace chamber at its lower part so as to supply the furnace chamber with combustion products including high temperature combustion gases with previously fused slag particles suspended therein, the temperature of the combustion gases being greater than the fusion temperature of the slag or ash of the coal, a multiple platen dog-leg tubular radiant superheater disposed in the upper part of the furnace chamber and bounding a large volume combustion gas space in the lower part of the chamber, groups of the platens being disposed at positions successively more remote from the position of entry of combustion products into the furnace chamber with the platens nearest said position being more widely spaced, each of the superheater platens presenting a flat structure including a multiplicity of dog-leg superheater tubes with horizontally inclined parts extending through the front wall of the furnace chamber and between its wall tubes and across a substantial part of the upflow of gases within the furnace chamber, said dog-leg superheater tubes also having vertically extending parts formed as continuations of the horizontally inclined parts and extending through the roof of the furnace chamber, inlet and outlet superheater headers connected to the lower ends of the superheater tubes and disposed exteriorly of said front wall, and means whereby vapor generated in the furnace chamber wall tubes is conducted to the superheater.

8. In a vapor generating and superheating unit, a vertically elongated large volume furnace chamber having a lateral gas outlet at its upper end, vapor generating tubes defining the walls and roof of the furnace chamber, coal burning means connected with the furnace chamber at its lower part so as to supply the furnace chamber with combustion products including high temperature combustion gases with previously fused slag particles suspended therein, the temperature of the combustion gases being greater than the fusion temperature of the slag or ash of the coal, a multiple platen dog-leg tubular radiant superheater disposed in the upper part of the furnace chamber and bounding a large volume combustion gas space in the lower part of the chamber, groups of the platens being disposed at positions successively more remote from the position of entry of combustion products into the furnace chamber with the platens nearest said position being more widely spaced, each of the superheater platens presenting a flat structure including a multiplicity of dog-leg superheater tubes with horizontally inclined parts extending through the front wall of the furnace chamber and between its wall tubes and across a substantial part of the upflow of gases within the furnace chamber, said dog-leg superheater tubes also having vertically extending parts formed as continuations of the horizontally inclined parts and extending through the roof of the furnace chamber, inlet and outlet superheater headers connected to the lower ends of the superheater tubes and disposed exteriorly of said front wall, and means whereby vapor generated in the furnace chamber wall tubes is conducted to the superheater, said last named means including tubular elements conducting the superheater entering vapor to the superheater platens most widely spaced and nearest the position of entry of combustion products into the furnace chamber so that the superheater vapor of lowest temperature passes through the superheater platens subject to the highest gas temperatures.

9. In a vapor generating and superheating unit, a vertically elongated large volume furnace chamber having a lateral gas outlet at its upper end, vapor generating tubes defining the walls and roof the the furnace chamber, coal burning means connected with the furnace chamber at its lower part so as to supply the furnace chamber with combustion products including high temperature combustion gases with previously fused slag particles suspended therein, the temperature of the combustion gases being greater than the fusion temperature of the slag or ash of the coal, and a multiple platen tubular radiant superheater disposed at the upper part of the furnace chamber and bounding a large volume combustion gas space in the lower part of the chamber, groups of the platens being disposed at positions successively more remote from the position of entry of combustion products into the furnace chamber with the platens nearest said position being more widely spaced transversely of gas flow, each of the superheater platens presenting a flat structure including a multiplicity of parallel and closely arranged superheater tubes extending through the roof of the furnace chamber, inlet and outlet superheater headers connected to the lower ends of the superheater tubes and disposed exteriorly of said front wall, and means whereby vapor generated in the furnace chamber wall tubes is conducted to the superheater, the spacing of the superheater platens in rows successively more remote from the entry of combustion products into the furnace chamber decreasing as the distance from said entry increases and the back-to-back

spacing of the tubes of each platen increasing with the increasing distance of the platen from said entry.

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