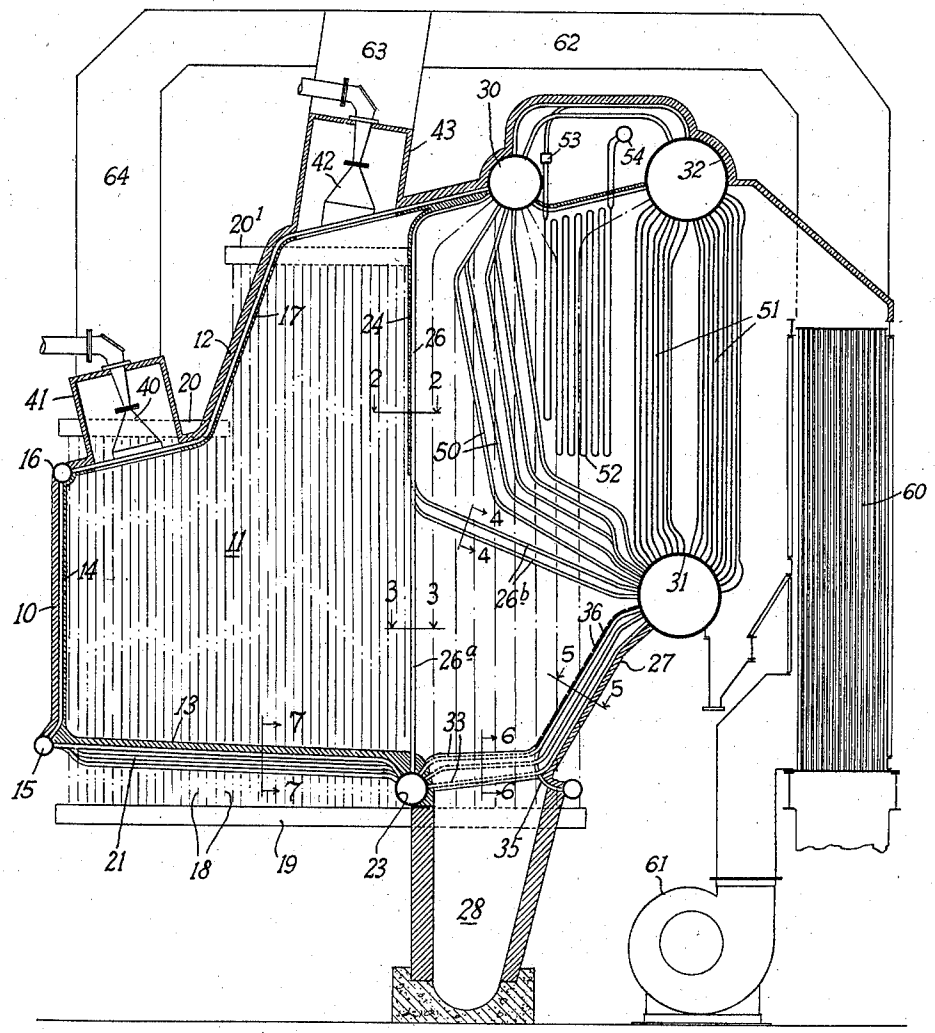
July 2, 1940. G. W. SAATHOFF 2,206,265

STEAM GENERATOR

Filed Oct. 16, 1937 3 Sheets-Sheet 1

Fig. 1



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STEAM GENERATOR

Filed Oct. 16, 1937 3 Sheets-Sheet 2

Fig. 2

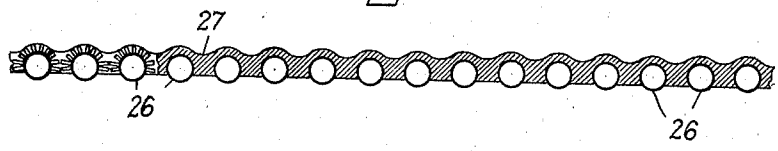


Fig. 3

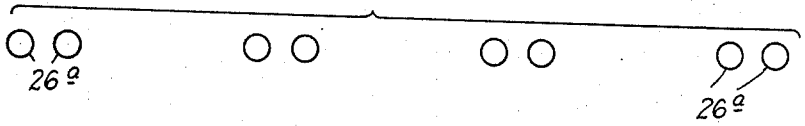


Fig. 4

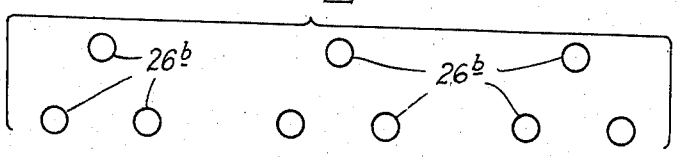


Fig. 5

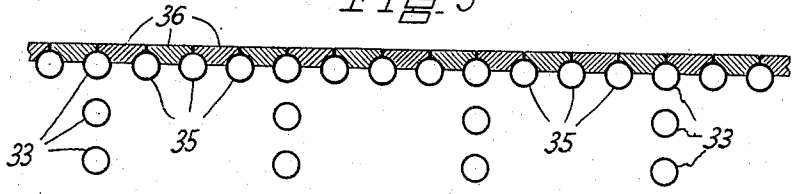


Fig. 6

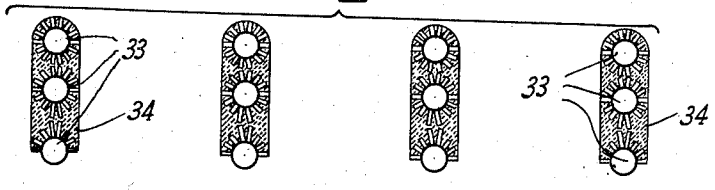
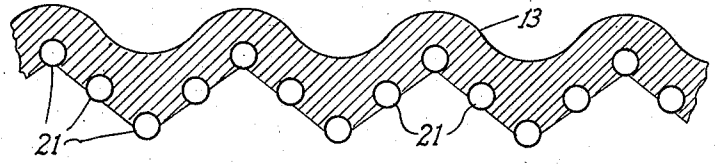


Fig. 7



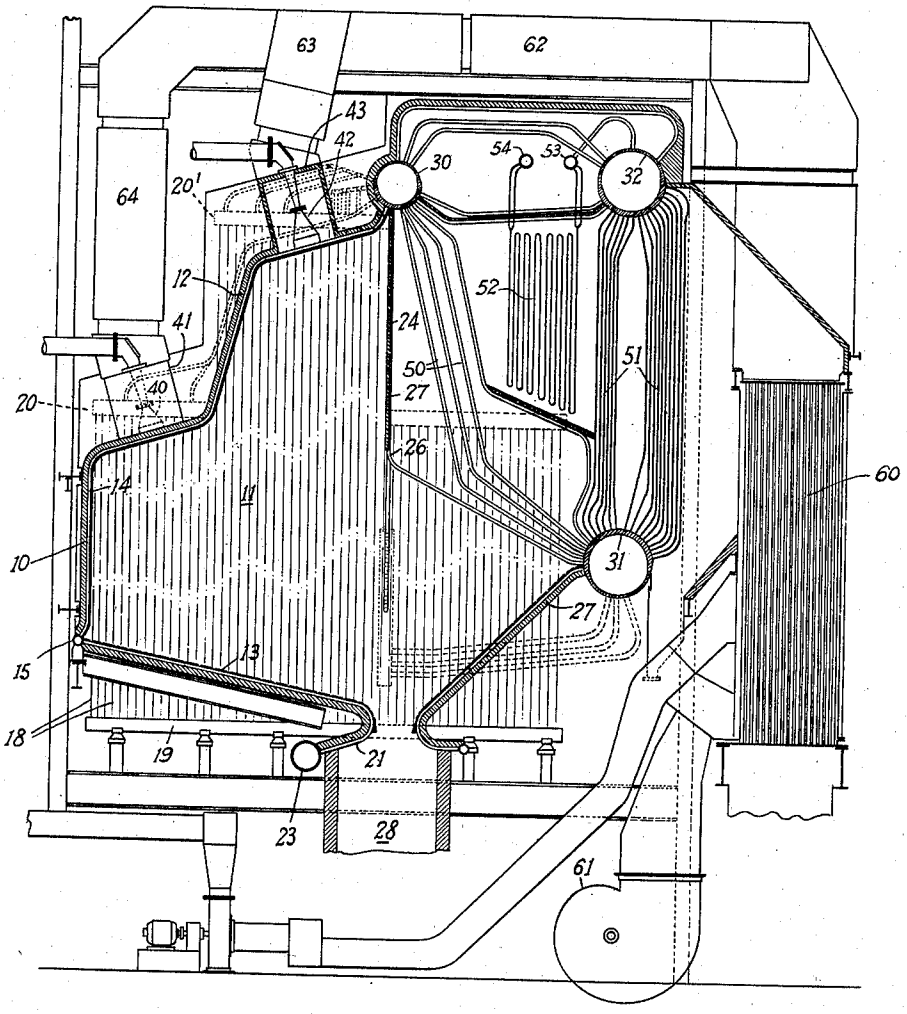
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July 2, 1940. G. W. SAATHOFF 2,206,265

STEAM GENERATOR

Filed Oct. 16, 1937 3 Sheets-Sheet 3

Fig. 8



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Patented July 2, 1940 2,206,265

UNITED STATES PATENT OFFICE

2,206,265

STEAM GENERATOR

George W. Saathoff, South Orange, N. J.

Application October 16, 1937, Serial No. 169,361

16 Claims. (Cl. 122—235.1)

The present invention relates to the construction and operation of steam generators, and more particularly to steam generators designed for the burning of finely divided solid fuel in suspension and steam generators incorporating a steam superheater within the space occupied by the convection heated portion of the steam generating surface.

Finely divided solid fuel, such as pulverized coal, has been heretofore burned in suspension under furnace conditions resulting in the deposition of the non-combustible residue or ash on the furnace bottom in either a dry or a molten condition, depending mainly upon the relation of the ash fusion temperature to the mean furnace temperature, and the temperature at the furnace bottom. In general, when the mean furnace temperature is lower than the ash fusion temperature, the ash will collect on the furnace bottom in a dry condition, and when above the ash fusion temperature the ash will collect in a molten condition. When the separated ash is in either a dry or molten condition, it may be readily removed while the furnace is in operation. When the ash is in an intermediate state of high viscosity, its removal while maintaining continuity of operation is extremely difficult.

Coals having a wide range of ash fusion temperature are now burned in pulverized fuel furnaces. Such furnaces are usually designed for a specified range of operating load with a certain kind of ash removal when burning pulverized coal having an ash fusion temperature within a certain range. In such furnaces, the furnace temperature will necessarily vary throughout the normal range of operation due to changes in the quantity of fuel burned.

It is also important in the operation of a steam generator unit of the character described to minimize the deposition of ash in a molten or sticky condition on the convection heated steam generating and superheating surface beyond the furnace, and to limit the variation in steam superheat temperature to a small range.

The main object of my invention is the provision of a steam generator including an improved furnace construction and method of operating the same adapted for the burning of finely divided solid fuel of substantially any ash fusion temperature over a wide range of operating load while obtaining the ash separating from the burning fuel in a condition suitable for easy removal while the furnace is in operation. A further object is the provision of a steam generator of the character described with a furnace construction and mode of operation permitting the separation and discharge of the ash in either a dry or molten condition as indicated to be preferable by the ash characteristics of the fuel in use. A further object is the provision of a steam generator of the character described with a construction and arrangement of the convection heated steam generating and superheating surface providing a high steam generating capacity, low draft loss, minimum slag deposits, and an inherent regulation of superheat temperature.

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

Of the drawings:

Fig. 1 is a partly diagrammatic sectional elevation of a steam generator constructed and adapted to operate in accordance with my invention;

Fig. 2 is a section taken on the line 2—2 of Fig. 1 with a portion of the refractory omitted;

Figs. 3, 4, 5, 6 and 7 are sections taken on the lines 3—3, 4—4, 5—5, 6—6, and 7—7 of Fig. 1 respectively, and

Fig. 8 is a view similar to Fig. 1 illustrating a modified construction.

The steam generator units illustrated in the drawings comprise in general a two-stage pulverized coal burning furnace, a three drum steam boiler of the vertical bent tube type, and an air heater, all relatively arranged as hereinafter described. In the construction shown in Figs. 1–7, the furnace is defined by a front wall 10, opposite side walls 11, a rearwardly stepped arch or roof 12, and a rearwardly sloping transversely corrugated floor 13. All of these boundary surfaces are fluid cooled by heat absorbing fluid conduit elements connected into the circulation system of the associated steam boiler. The front wall 10 has vertical water tubes 14 extending between transverse headers 15 and 16; the arch 12 has water tubes 17 extending between the front wall header 16 and the front upper drum of the boiler; the side walls 11 have vertical water tubes 18 extending between a bottom header 19 and upper headers

20 and 20' arranged at different elevations; and the furnace bottom 13 has water tubes 21 extending between the front wall header 15 and a a transverse header 23 below the rear end of the floor.

The furnace is divided by a transverse baffle or partition structure 24 into a primary or high temperature section and a rearwardly adjoining secondary or low temperature section communicating at their lower ends. The partition structure 24 extends downwardly from the rear part of the furnace arch in substantially vertical alignment with the rear end of the floor 13. The partition extends through approximately the upper half of the furnace forming the rear wall of the primary section and leaving a gas exit from the primary section to the secondary section below the lower end of the partition As shown in Figs 1 and 2, the partition is formed by a transverse row of water tubes 26 having their upper ends bent rearwardly and connected to the front upper boiler drum 30 The portions of the tubes 26 forming the partition are provided with metallic studs, as shown in Fig 2, projecting at their front sides and into the intertube spaces. Refractory material 27 is applied to cover the studs and close the spaces between the tubes 26

The portions of the tubes 26 below the partition 24 are arranged to form spaced tube screens across which the furnace gases from the primary section must pass before contacting with the main convection heating surface of the steam boiler. As shown in Figs. 1, 3 and 4, transversely spaced pairs of tubes, designated 26^a, are continued vertically downward to the floor 13 and connected to the header 23. The remaining tubes, designated 26^b, are bent downwardly and rearwardly in a staggered formation, as shown in Fig. 4, with their lower ends connected to the bottom drum 31 of the boiler. The space between the rear side of the partition 24 and screen tubes 26^a and the main convection surface of the boiler forms the secondary or low temperature section of the furnace. While, as indicated in Fig. 1, it is desirable to wholly or partly cover the tubes along the boundaries of the primary furnace section with refractory material to secure the desired rate of heat absorption in that section, the tubes along the boundaries of the secondary furnace section are preferably left bare to obtain a higher rate of heat absorption. The heat release rates and heat absorbing surface in the two furnace sections are proportioned so that the normal mean furnace temperature in the primary section will be substantially higher than that in the secondary section.

The bottom of the secondary section is partly defined by an inclined rear wall 27 and an ash hopper 28. Transversely spaced groups of vertically aligned tubes 33 extend across the upper end of the ash hopper 28 from the header 23 and thence upwardly along the wall 27 to the lower boiler drum 31. As shown in Fig. 6, the portions of the tubes 33 directly above the hopper are studded and covered by refractory 34. The spaces between the tube groups 33 along the front side of the wall 27 are occupied by a row of tubes 35 in transverse alignment with the innermost row of tubes 33 so that these tubes can be covered with metallic blocks 36 to form an inclined receiving surface facilitating the conveyance of depositing ash or slag into the hopper 28.

The furnace arch 12 is formed by slightly inclined front and rear sections at substantially different elevations connected by a steeply inclined intermediate section, with the tubes 17 bent correspondingly. A transversely spaced group of fuel burners 40 of the type shown in Hardgrove patent #2,055,722 is arranged to discharge streams of pulverized coal and primary air through the front arch section downwardly and rearwardly into the furnace in a direction substantially normal to the arch. Each of the burners 40 is enclosed by an air box or compartment 41 which supplies preheated secondary air around and between the various fuel streams. A similar group of fuel burners 42 and air boxes 43 are arranged to discharge through the rear arch section downwardly and somewhat forwardly into the furnace diverging at an acute angle relative to the partition 24. With the described fuel burner arrangement, in operation the burning fuel streams from the low level burners 40 will pass downwardly and slightly rearwardly to the floor 13 and then horizontally along the floor to the gas exit formed below the partition 24. With the low level burners 40 in use the furnace temperature adjacent the floor 13 will be relatively high and normally above the ash fusion temperature of the coal. The described fuel path would thus convert or maintain any ash or slag deposited on the floor in a molten condition. The path of the burning fuel streams from the high level burners 42 however is mainly vertical, bending horizontally at its lower end toward the gas exit across the tubes 26^a. The fuel streams from the high level burners will have a substantially longer path of travel downwardly in the furnace than the streams from the low level burners and sweep at the most only a small portion of the floor. This fuel path in conjunction with the substantial amount of radiant heat absorbing surface throughout its length is conducive to a more uniform distribution of the heat released throughout the furnace and the maintenance of any ash depositing on the furnace floor in a dry condition. Each set of fuel burners is capable of supplying the maximum fuel requirements of the unit. In accordance with my preferred mode of operation, the furnace is normally operated so as to secure the deposition of ash on the furnace floor in a dry condition, but if, due to changes in the rate of heat release necessitated by variations in the load, the furnace conditions become such that the ash deposited on the floor is or tends to become sticky, rendering it extremely difficult to be removed while the furnace is in operation, then the method of fuel introduction is changed to insure the ash depositing on the furnace floor being molten, and thus in a condition to permit its flow over the rear end of the floor to the ash hopper.

The fuel requirements of most pulverized coal burning steam plants are supplied at all times by coal having substantially similar combustion characteristics. When the furnace construction described is in use in such a plant, only the high level burners 42 are used at low and moderate operating loads and the low level burners 40 are idle, although secondary air can be supplied from the air boxes 41 if desirable. In view of the resulting path of travel of the burning fuel from the burners 42, the normal mean furnace temperature under these conditions will be relatively low, and the ash separated will deposit and can be readily removed in a dry condition by raking or blowing the same off the furnace floor 13 between the tubes 26^a into the hopper 28. As the operating load increases, a corresponding increase

in the fuel supply to the furnace must be made with a resulting rise in furnace temperature. When the coal has a relatively low ash fusion temperature, the separated ash tends to become sticky and fuse on any substantial increase in load. Accordingly, on such an increase in the boiler load, with a relatively low ash fusion temperature coal in use, the high level burners 42 are wholly or partly shut down and the fuel wholly or partly delivered to the low level burners 40, the amount of coal still introduced through the high level burners depending primarily on the furnace volume required for optimum combustion conditions. With the described fuel stream path from the burners 40, the furnace temperature in the floor zone will be substantially increased and the ash deposited on the furnace floor can be easily melted or maintained in a molten condition. The molten ash flows down the inclined floor 13 between the tubes 26a and tube groups 33 into the hopper 28 from which it can be sluiced in a well known manner. With the foregoing method of operation low ash fusion temperature coal can be burned under desirable conditions for complete combustion in the main furnace chamber and separated ash collected on the furnace floor in a readily removable form over a wider range of load than is possible in other furnaces.

The furnace construction and burner arrangement described are also particularly adapted for use in steam plants where the use of a plurality of coals having substantially different ash fusion temperatures is desirable from an economic standpoint. In such plants when the normal mean furnace temperature at the desired rate of heat release is below the ash fusion temperature of the high ash fusion coal, the high level burners 42 alone are used for the high ash fusion coal and the ash removed in a dry condition. When the contemplated normal mean temperature is adjacent or above the ash fusion temperature of the low ash fusion coal, the low level burners 40 alone are used to introduce low ash fusion coal and the ash removed in a molten condition. At low loads, the furnace temperature conditions will usually be such that low ash fusion coal may be introduced through the high level burners alone and the ash removed in a dry condition.

Under all conditions the furnace gases leave the main furnace chamber through the gas exit openings between the tubes 26a and turn upwardly at the rear thereof. In view of the cooling effect of the tubes 26a and the substantial amount of radiant heat absorbing surface in the secondary furnace section, the temperature of the gases will be rapidly reduced and any ash remaining in suspension, if fused or molten, will be cooled to a dry condition. Ash separating in the secondary section whether originally dry or solidified therein by cooling will drop into the hopper 28 and be removed simultaneously with the dry ash or slag from the primary furnace section.

In view of the relatively high location of the high level burners, it is possible to locate the boiler convection heating surface at one side of the furnace and within the height of the furnace, thereby minimizing the head room required for the unit. The convection surface comprises a front bank of vertically disposed widely spaced bent tubes 50 extending between the drums 30 and 31 and spaced rearwardly from the partition 24, and a divided bank of tubes 51 vertically arranged between the drum 31 and the rear boiler drum 32. The upper drums 30 and 32 are connected by steam circulators and water circulators in the usual manner, and the drum 32 connected to the inlet end of a steam superheater 52 formed by multiple looped flat coils arranged side-by-side the full width of the boiler and having their opposite ends connected to an inlet header 53 and outlet header 54 respectively. The superheater tube coils extend downwardly from the top of the setting and terminate a substantial distance above the level of the drum 31 for a purpose hereinafter set forth. The steam boiler is of the single pass type, no baffles being associated with the tube banks or superheater, with a resulting low draft loss through that portion of the unit.

The spaced arrangement of the tube bank 50 relative to the partition 24 and the location of the gas exit from the primary furnace section at the lower rear side thereof forms in effect a vertical gas pass through which the hot furnace gases tend to rise, particularly at low loads, by reason of their own low density independent of the effect of any other draft inducing apparatus. The tubes in the outermost rows of the bank 50 are relatively widely spaced from one another, aiding in the formation of this vertical gas pass of relatively low flow resistance at the rear side of the partition. The furnace gases from the top of the vertical gas pass flow horizontally over the tube bank 51 and then enter the upper end of a tubular air heater 60 which is connected to the space at the rear of the tube bank 51 adjacent the upper end thereof. At low loads the colder gases tend to collect in the lower part of the boiler setting. This natural stratification of the gases is particularly noticeable at low loads when the effect of the draft inducing mechanism is relatively small. As the load increases the greater volume of gases flowing through the boiler and the increased effect of the draft inducing mechanism causes a more uniform distribution of the gas flow across the boiler tube banks. The gases pass down through the air heater tubes to a stack connection. A forced draft fan 61 and conduits 62, 63, and 64 provide a circulation of air under pressure through the air heater to the secondary air boxes 41 and 43.

Under light load conditions most of the furnace gases on leaving the primary furnace chamber will pass vertically upward at the rear side of the partition 24 and then substantially horizontally across the tube bank 50, superheater 52 and tube bank 51 to the air heater 60, the stack effect of the vertical gas pass contributing substantially to this path of gas flow. As the boiler load increases and consequently the volume of furnace gases, a more uniform distribution of the gas flow will occur throughout the height of the horizontal path across the convection surface. The boiler is proportioned so that at full load all of the heating surface is equally active across the horizontal portion of the gas path from its top to its bottom, while at light loads the part near the top will be subjected to a greater gas flow than the part near the bottom.

This variation in gas distribution from the top to the bottom of the convection surface in the horizontal gas pass is advantageously utilized by the described arrangement of the superheater tubes 52 to limit the range of variations in superheat temperatures. When superheating surface is swept by all of the heating gases at all loads,

it is well known that the final superheat temperature will rise with increases in load, and the undesirability of this result has been responsible for the various schemes that have been heretofore suggested for by-passing some of the furnace gases at higher loads. The present superheater arrangement provides an inherent control of superheat temperatures in that the superheating surface is restricted to the upper portion of the horizontal gas pass. At very light loads the horizontal gas stream may extend down from the top for only part of the length of the vertical superheater tubes, but with increase of load the gas stream will extend farther down and so the active heating surface will vary with load. Proportions may be selected so that substantially all of the superheating surface will be in the main path of the gases even at light loads. The space between the lower end of the superheater and the bottom drum 31 will receive a larger fraction of the gases at high loads than at low loads, and correspondingly decrease the fraction of the gases contacting with the superheating surface. The arrangement described thus provides superheat control without any special flow control devices.

In Fig. 8 is illustrated the construction shown in Figs. 1–7 as embodied in a central station installation, corresponding parts being designated by like reference numerals. The main differences reside in the construction and arrangement of the partition tubes, the location of the front upper drum, a reversed arrangement of the superheater connections, and the use of a special superheater baffle and baffle supporting tubes.

While in accordance with the provisions of the statutes I have illustrated and described herein the best forms of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

I claim:

1. A furnace for burning finely divided solid fuel comprising walls defining the sides of a furnace chamber, an arch having burner ports at substantially different elevations therein, a closed floor forming the bottom of said furnace chamber, and fuel burners arranged to discharge streams of finely divided solid fuel through said burner ports downwardly towards said floor through flame paths of substantially different lengths relative to said floor.

2. A furnace for burning finely divided solid fuel comprising walls defining the sides of a furnace chamber having a gas exit in the lower part of one of the side walls, an arch having burner ports at substantially different elevations therein, a floor forming the bottom of said chamber, and fuel burners arranged to discharge streams of finely divided solid fuel through said burner ports downwardly towards said floor through flame paths of substantially different lengths relative to said gas exit.

3. A furnace for burning finely divided solid fuel comprising vertically disposed front, side and rear walls defining the sides of a furnace chamber having a gas exit in said rear wall, a closed floor forming the bottom of said chamber, a stepped arch forming the roof of said furnace chamber and having burner ports therein at substantially different elevations, the burner port at the higher elevation being nearer to the rear wall of the furnace chamber, and separate fuel burners arranged to discharge streams of finely divided solid fuel through said burner ports toward said floor through flame paths of substantially different lengths relative to said floor.

4. A furnace for burning finely divided solid fuel comprising vertically disposed front, side and rear walls defining the sides of a furnace chamber having a gas exit in said rear wall, a closed fluid cooled inclined floor sloping towards its rear end, an ash hopper at the rear end of said floor adjacent said gas exit, a stepped arch forming the roof of said furnace chamber and having burner ports therein at substantially different elevations, the burner port at the higher elevation being nearer to the rear wall of the furnace chamber, and separate fuel burners arranged to discharge streams of finely divided solid fuel through said burner ports toward said floor through flame paths of substantially different lengths relative to said floor.

5. The method of operating a furnace having fluid-cooled walls and pulverized fuel burners arranged at substantially different lengths of fuel travel in the furnace relative to the furnace floor which comprises at low loads introducing pulverized fuel through the burners having the longer length of fuel travel in the furnace chamber and burning the fuel in suspension while passing through a flame path towards the furnace floor and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor below the ash fusion temperature and cause ash separating from the fuel stream to collect on the floor in a dry condition, and at high loads introducing fuel through the burners having the shorter length of fuel travel in the furnace chamber and burning the fuel in suspension while passing through a flame path sweeping across the furnace floor and of substantially less length than the flame path at low loads and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor above the ash fusion temperature and cause separating ash to collect on the floor in a molten condition.

6. The method of operating a furnace having fluid-cooled walls and pulverized fuel burners arranged to downwardly discharge at substantially different levels in the furnace which comprises at low loads introducing pulverized fuel having a relatively low ash fusion temperature through the high level burners and burning the fuel in suspension while passing through a flame path towards the furnace floor and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor below the ash fusion temperature and cause ash separating from the fuel stream to collect on the floor in a dry condition, and at higher loads introducing fuel through the low level burners and burning the fuel in suspension while passing through a flame path sweeping across the furnace floor and of substantially less length than the flame path at low loads and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor above the ash fusion temperature and cause separating ash to collect on the floor in a molten condition.

7. The method of burning a finely divided solid fuel having a relatively low ash fusion temperature in a fluid-cooled furnace chamber over a wide operating range while causing separated ash to collect in a readily removable condition on the furnace floor which comprises burning the fuel in suspension at high loads while passing through

a flame path sweeping across the furnace floor and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor above the ash fusion temperature to cause ash separating from the fuel stream to collect on the floor in a molten condition, and burning the fuel in suspension at low loads while passing through a flame path of substantially greater length relative to the floor than the flame path at high loads and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor below the ash fusion temperature to cause ash separating from the fuel stream to collect on the floor in a dry condition.

8. The method of operating a furnace having fluid-cooled walls and pulverized fuel burners arranged at substantially different lengths of fuel travel in the furnace relative to the furnace floor which comprises at one time introducing pulverized fuel having a relatively low ash fusion temperature through the burners having the shorter length of travel and burning the fuel in suspension while passing through a flame path sweeping across the furnace floor and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor above the ash fusion temperature and cause ash separating from the fuel stream to collect on the floor in a molten condition, and at another time introducing pulverized fuel having a higher ash fusion temperature through the burners having the longer length of fuel travel in the furnace chamber and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor below the ash fusion temperature and cause ash separating from the fuel stream to collect on the floor in a dry condition.

9. The method of operating a furnace having pulverized fuel burners arranged to downwardly discharge at substantially different levels in the furnace which comprises at one time introducing pulverized fuel having a relatively low ash fusion temperature through the low level burners and burning the fuel in suspension while passing through a flame path sweeping across the furnace floor and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor above the ash fusion temperature and cause ash separating from the fuel stream to collect on the floor in a molten condition, and at another time introducing pulverized fuel having a higher ash fusion temperature through the high level burners and burning the fuel in suspension while passing through a flame path of substantially greater length than the flame path of the lower ash fusion temperature fuel and at a heat release rate sufficient to maintain a furnace temperature adjacent the floor below the ash fusion temperature and cause ash separating from the fuel stream to collect on the floor in a dry condition.

10. A steam generator comprising a furnace chamber, a partition arranged to divide said furnace chamber into primary and secondary sections serially connected below said partition, convection heated steam generating and superheating surface adjacent one side of said partition receiving furnace gases from said secondary furnace section and including a plurality of vertically disposed banks of water tubes having a gas flow mainly transversely of the tubes thereof, and a steam superheater positioned between said tube banks and having its lower end terminating above the lower end of said tube banks to provide a gas by-pass from said secondary furnace section around the lower end of said superheater.

11. A steam generator comprising a furnace chamber, a partition arranged to divide said furnace chamber into front and rear sections serially connected below said partition, convection heated steam generating and superheating surface adjacent the rear side of said partition receiving furnace gases from said rear furnace section including a plurality of transverse upper drums, a transverse lower drum, vertically disposed banks of water tubes connecting said upper drums to said lower drum having a gas flow mainly transversely of the tubes thereof, and a steam superheater positioned between said water tube banks and having its lower end spaced from said lower drum to provide a gas by-pass from said rear section between the lower end of said superheater and said lower drum.

12. A steam generator comprising a furnace chamber, a partition arranged to divide said furnace chamber into front and rear sections serially connected below said partition, a closed floor forming the bottom of said front furnace section, an ash hopper at the rear end of said floor forming the bottom of said rear furnace section, tubes extending downwardly along said partition and having their lower end portions relatively arranged to form a plurality of relatively angularly arranged tube screens, convection heated steam generating and superheating surface at the rear side of said partition and above said rear furnace section including a plurality of transverse upper drums, a transverse lower drum, vertically disposed banks of water tubes connecting said upper drums to said lower drum, and a steam superheater positioned between said water tube banks.

13. A steam generator comprising a furnace chamber, a partition arranged to divide said furnace chamber into front and rear sections serially connected below said partition, a floor forming the bottom of said front furnace section, an ash hopper at the rear end of said floor forming the bottom of said rear furnace section, convection heated steam generating and superheating surface adjacent the rear side of said partition and above said rear furnace section including a plurality of transverse upper drums, a transverse lower drum, vertically disposed banks of water tubes connecting said upper drums to said lower drum and having a gas flow mainly transversely of the tubes thereof, and a steam superheater positioned between said water tube banks.

14. A steam generator comprising a furnace chamber, a partition arranged to divide said furnace chamber into front and rear sections serially connected below said partition, a floor forming the bottom of said front furnace section, an ash hopper at the rear end of said floor forming the bottom of said rear furnace section, tubes extending downwardly along said partition and having their lower end portions relatively arranged to form a plurality of relatively angularly arranged tube screens, convection heated steam generating and superheating surface at and spaced from the rear side of said partition and above and at the side of said rear furnace section including a plurality of transverse upper drums, a transverse lower drum, vertically disposed banks of water tubes connecting said upper drums to said lower drum, and a steam superheater positioned between said water tube banks and having its lower end spaced from said lower drum to provide a gas by-pass from said rear furnace

section between the lower end of said superheater and said lower drum.

15. A steam generator comprising a furnace chamber, a partition arranged to divide said furnace chamber into front and rear sections serially connected below said partition, a closed floor forming the bottom of said front furnace section, fuel burners arranged at substantially different elevations relative to said floor arranged to discharge streams of finely divided solid fuel towards said floor, an ash hopper at the rear end of said floor forming the bottom of said rear furnace section, tubes extending downwardly along said partition and having their lower end portions relatively arranged to form a plurality of angularly arranged tube screens, convection heated steam generating and superheating surface at and spaced from the rear side of said partition and above and at the side of said rear furnace section including a plurality of transverse upper drums, a transverse lower drum, vertically disposed banks of water tubes connecting said upper drums to said lower drum, and a steam superheater positioned between said water tube banks and having its lower end spaced from said lower drum to provide a gas by-pass from said rear furnace section between the lower end of said superheater and said lower drum.

16. The method of burning two pulverized coals of substantially different ash fusion temperatures in the same fluid cooled furnace which comprises at one time introducing the pulverized coal having the higher ash fusion temperature into the furnace at a point providing a relatively long length of fuel travel in the furnace towards the furnace bottom and a heat release rate maintaining a furnace temperature adjacent the furnace bottom below the ash fusion temperature, whereby ash separating from the fuel stream will deposit on the furnace bottom in a dry condition, and at another time introducing the pulverized coal having the lower ash fusion temperature into the furnace at a point providing a substantially shorter length of fuel travel in the furnace towards the furnace bottom and a heat release rate maintaining a furnace temperature adjacent the furnace bottom above the ash fusion temperature, whereby ash separating from the fuel stream will deposit on the furnace bottom in a molten condition.

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