

Dec. 9, 1958 P. H. KOCH 2,863,424
STEAM GENERATING, SUPERHEATING AND REHEATING UNIT
WITH DUAL FURNACES AND PARALLEL GAS PASSES
Filed Nov. 30, 1955 4 Sheets-Sheet 1

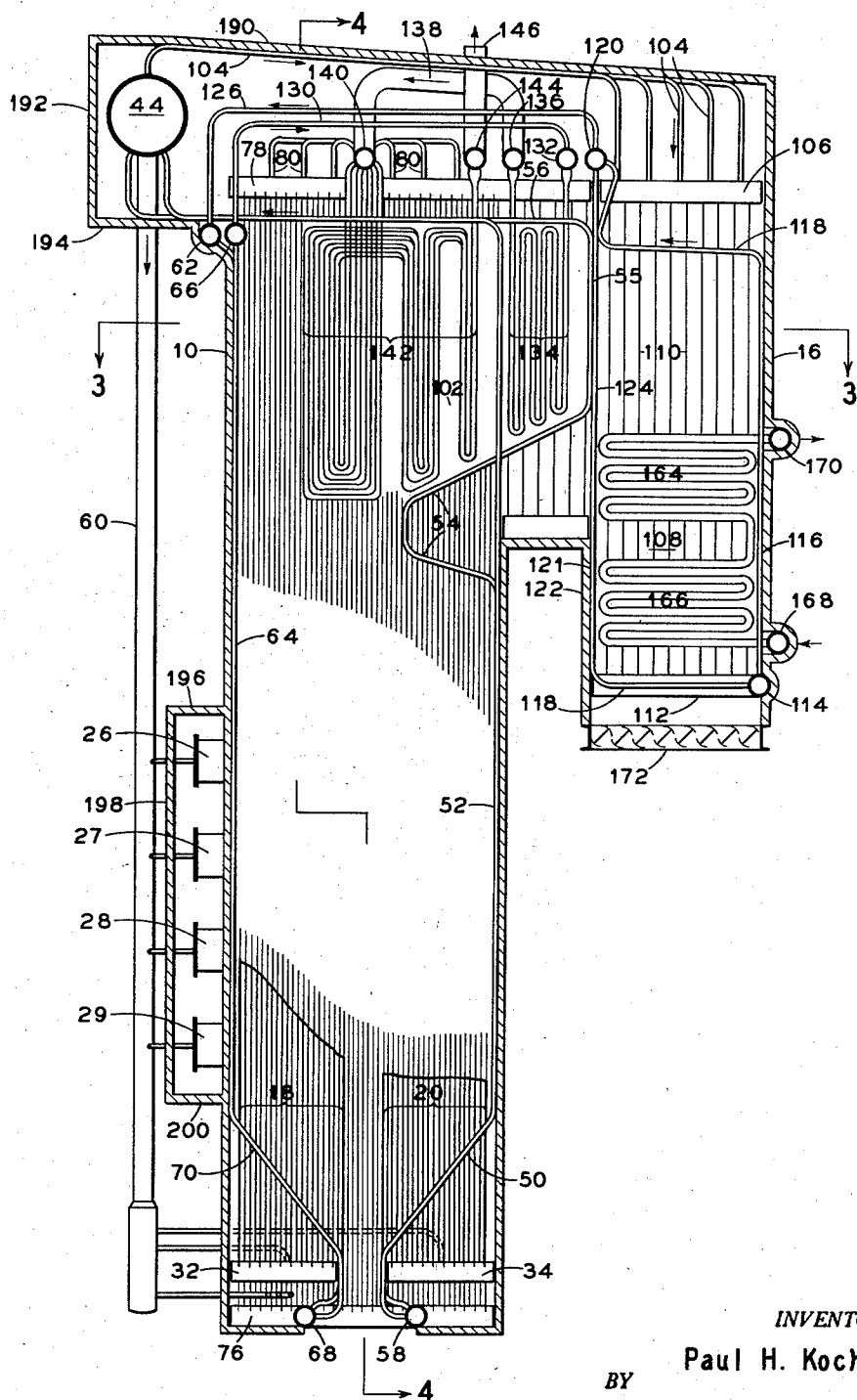
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4 Sheets-Sheet 2

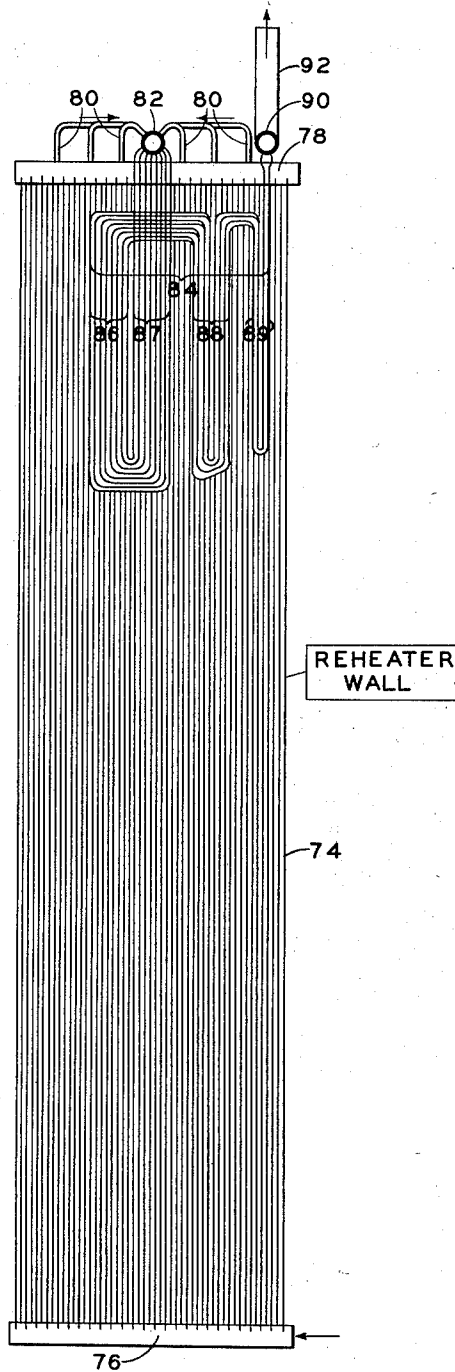


FIG 2

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2,863,424

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4 Sheets-Sheet 3

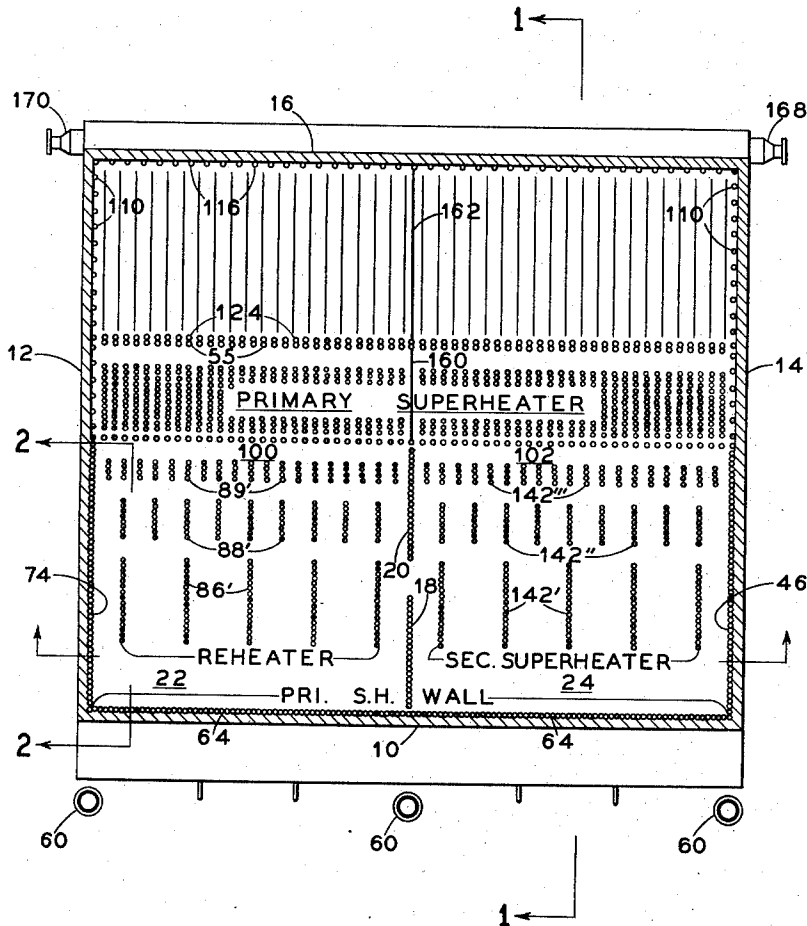


FIG 3

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2,863,424

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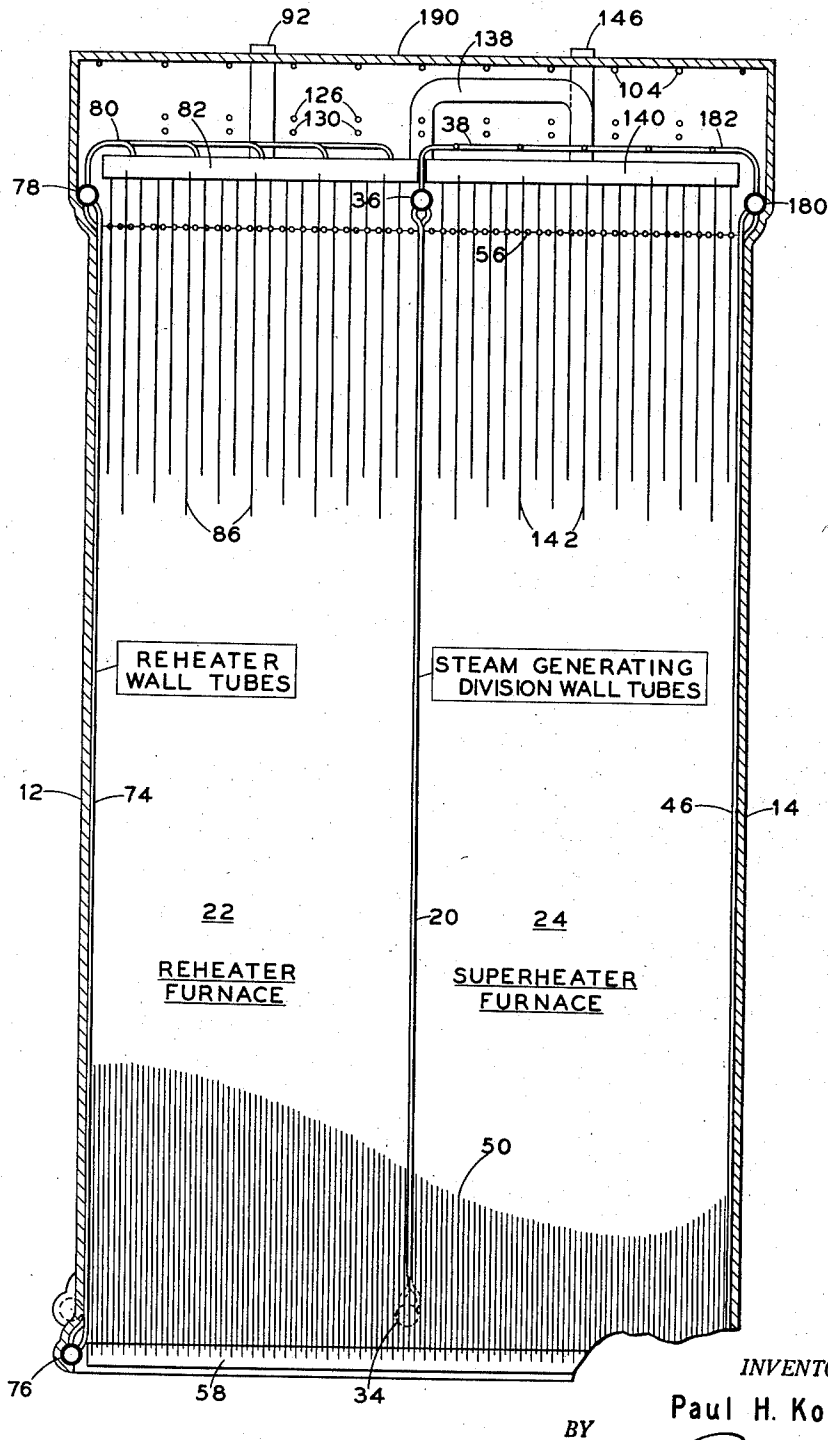


FIG. 4

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1

2,863,424

STEAM GENERATING, SUPERHEATING AND REHEATING UNIT WITH DUAL FURNACES AND PARALLEL GAS PASSES

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Application November 30, 1955, Serial No. 550,064

2 Claims. (Cl. 122—240)

This invention relates to the art of steam generation, steam superheating, and steam reheating.

High pressure and high capacity steam generating installations operating at high steam and reheat temperatures, with capacities of the order of one million pounds of steam per hour or more, and with the pressure in excess of two thousand p. s. i., and with steam superheat temperatures of the order of eleven hundred degrees F., and with reheat temperatures of a similar order, have long been recognized as desirable objectives, in the interest of the production of high pressure steam efficiently and economically. This invention relates to such installations of steam generating units.

Among the optimum attributes of a steam generating unit of the pertinent type is the maintenance of superheated steam temperatures and reheated steam temperatures at a predetermined value, or values, over a wide load range, and this invention with its separately fired combustion zones, one for reheat, and the other for superheat, and with its particular combination of predominantly radiantly heated and predominantly convection heated components for both the reheater and the superheater promotes the attainment of the desired superheat and reheat temperature control over a wide load range.

Among the other difficulties in realizing the general objective above indicated has been the problem of accomplishing these results with a highly efficient heat cycle, and with economy, not only as to the physical construction of the units, but also as to the efficiency of combustion and other components of the operation. Efficiency of the heat cycle with or without economy in construction is not sufficient, but these must be realized in a practical way insofar as operating conditions are concerned, such, for example, as difficulties arising in connection with the fuel, with the temperature to which the various parts of the unit are to be subjected, and other difficulties.

While it may be contemplated that any particular steam generating unit of the pertinent type may initially burn gas or oil, or other prepared fuel, the unit must be such, that, for practical purposes, it is possible to change from one type of fuel to another, including coal as a basic fuel, with a minimum of adaptive changes as to burners and air supply, and with no change in the generating and steam heating equipment, as this would involve what would be, in effect, reconstruction of the unit. Coal, for example, may at one time be of high quality and of high melting point ash, or it may, at another time, be of poor quality with low melting point ash and thereby present heat transfer difficulties such as the slagging of convection surfaces, if temperature conditions are not kept within certain limits. Again, no matter what the fuel, the maximum temperature to which the various heat transfer surfaces may be subjected is of great importance from the standpoint of economy or long life. Even as to the steam heating surfaces—(superheat and reheat)—the greater the quantity of heat resistant alloy

2

which has to be employed, the higher the cost; likewise, nothing is gained from the standpoint of economy and construction if excessive amounts of heating surface for superheaters and reheaters are required to realize the objective or, from the standpoint of efficiency if fuel is not effectively burned.

Merely by way of partial illustration, to obtain high capacity with high steam and reheat temperatures, with previously suggested designs of steam generating units involving convection superheaters and reheaters, they would require furnace outlet temperatures too high to permit substantially slag free operation with coal of even normal quality; the amount of superheater and reheater surfaces are excessive; and there is inability to maintain the temperature of steam superheating and reheating within allowable limits over a wide load range, the latter being one of the most important considerations, from the standpoint of efficiency of operation.

Again, there is the factor of the ability to get the installation into initial operation without expansion and contraction difficulties, or overheating of materials, and to get the installation quickly back on the line after banking, without such difficulties. Because of these difficulties (in both the turbine and the installation itself) it ordinarily takes considerable time to get the installation back on the line.

High capacity steam generating units of the pertinent type are, of necessity, very large, and their important operative components must be suspended from an overhead position by supporting structure which constitutes a very substantial portion of the cost of the whole unit.

One of the objects of the present invention is to provide a steam generating, superheating, and reheating unit which realizes the above indicated essential objectives in an economical manner, both from the standpoint of the physical construction, and from the standpoint of efficiency of operation.

The pertinent type of unit burns fuel and generates steam in separately fired combustion zones and the superheating, reheating, economizer, and air heating surfaces are arranged in such a manner as to obtain a highly effective utilization of the heat generated. The optimum results are attained in a unit in which there are separated gas flows from the separately fired combustion zones, with the control of heating gases in the separate gas passes controlled by variation in the rates of firing in the separate combustion zones, and by regulation of the gas flow at positions near the outlet ends of the gas passages.

The operation of the pertinent steam generating unit involves the generation, superheating, and reheating of steam in a power plant having a turbine, including the steps of producing separate streams of gases, or separately burning fuel in separate combustion zones, separately flowing the gas streams in radiant heat exchange relationship with steam generating surfaces, and thereafter heating steam by flowing each of said streams separately in heat exchange relationship with steam heating surfaces, whether they be superheating surfaces or reheating surfaces. The operation of the pertinent unit involves large combustion zones in which heat is predominantly radiantly transmitted to steam generating surfaces, to steam superheating surfaces in a part of at least one of the combustion zones, and to steam reheating surfaces in at least a part of another of the combustion zones.

The invention also involves a steam generating, superheating, and reheating unit in which the steam generating sections have tubular water wall linings adapted to be subjected to radiant heat, and means for firing fuel in each of said combustion zones to produce a stream of gas therein; the unit comprising a gas pass leading from each of the combustion zones with the flow of gases through the gas passes being entirely separate; the large

3

volume combustion chambers involving hopper bottom units in which the hopper walls and associated walls of the unit, from top to bottom, constitute steam superheating or steam reheating surfaces in particular relationship to convection steam heating and steam reheating surfaces subject to gas flow in the separate gas passes.

The invention will be set forth in concise manner in the claims appended hereto, but for a more complete understanding of the invention, its uses, and advantages, recourse should be had to the following description which refers to the accompanying drawings illustrating a preferred embodiment of the invention.

In the drawings:

Fig. 1 is a sectional side elevation, or vertical section through the superheater furnace and superheater side of the pertinent unit, on the line 1—1 of Fig. 3, and looking in the direction of the arrows;

Fig. 2 is a fragmentary elevation on the line 2—2 of Fig. 3 and looking in the direction of the arrows, this figure showing the arrangement and association of the predominantly radiantly heated and predominantly convection heated components of the reheater;

Fig. 3 is a plan section taken on the line 3—3 of Fig. 1; and

Fig. 4 is a vertical section indicating the two combustion zones or combustion chambers of the unit, taken on the line 4—4 in Fig. 1.

As indicated in the drawings, and more particularly in Fig. 3, the pertinent unit is of rectangular cross-section having a front wall 10, side walls 12 and 14, and a rear wall 16. Parts of these walls, together with the tubes of the furnace division wall components 18 and 20 define a reheater furnace or combustion chamber 22, and a superheater furnace or combustion chamber 24.

Each furnace or combustion chamber has its own set of burners such as those indicated at 26—29 in Fig. 1, for differential firing of the combustion chambers or furnace sections, in the interest of controlling steam superheat and reheat temperatures. These fuel burners are preferably combination burners, capable of burning a variety of fuels such as oil, gas and coal, with possibly more than one of the fuels being burned simultaneously.

It is within the purview of the invention that there may be four widely vertically spaced horizontal rows of burners 26—29 for each of the furnaces. With this arrangement of burners there may not only be differential firing of the burners for the different furnace sections, in the interest of maintaining predetermined superheat and reheat temperatures, but there may be also differential firing between the separate and widely spaced different horizontal rows of burners for each furnace section in the interest of maintaining superheat and/or reheat temperature at a desired value over a wide range of load, or rating. For example, if the superheat temperature tends to fall at any time, the burners of the upper row 26 (or upper rows 26 and 27) may have their rate of firing increased, to increase the temperature of the gases contacting the superheater, and therefore increase the superheat temperature. Similar action may take place in the reheater furnace.

The firing of the furnaces 22 and 24 by the fuel burners results in the development of high temperature gases within the separate furnaces, the temperature of the gases being within the range of 2000 degrees F. to 3000 degrees F.

Within the furnace sections 22 and 24 heat is predominantly radiantly transmitted to heat absorbing tubes for the purpose of steam generation, also for the purpose of steam heating. The upright tubes of the division wall components 18 and 20 are steam generating tubes leading upwardly from such headers as those indicated at 32 and 34 in Fig. 1, to an upper header 36 (Fig. 4) from which steam and water mixtures flow through appropriate circulators, such as 38, to the steam and water drum 44. Steam is also generated within the superheater furnace

4

chamber 24 by the wall tubes 46 arranged along a part of the side wall 14 (Fig. 3) and appropriately connected into the circulation of the unit in a manner similar to that indicated for the division wall tubes 18 and 20.

Also, within the superheater furnace radiantly transmitted heat is absorbed for the purpose of steam generation in the hopper bottom tubes 50, the upper parts of which lead along the rear furnace wall 52, past the arch 54, then in screened formation 55 at the end of the horizontal gas pass at the upper part of the unit and thence through the roof tube portions 56 to the drum 44.

These steam generating tubes communicate at their lower ends with the header 58 which, in the operation of the unit, is adequately supplied with vaporizable liquid through appropriate circulators connecting the large diameter downcomer 60 with the header.

Other heat absorptive surfaces for the superheater furnace 24 are provided by the tubes 64 along the front wall 10 of that furnace. These tubes constitute part of an intermediate component of the superheater. The arrangement is preferably such that steam flows downwardly from the superheater inlet header 62 through half of these tubes, and the steam flow is upwardly through the remainder of these tubes to the outlet header 66, there being appropriate provisions at the position of the hopper bottom header 68, for this purpose. The lower part of these superheater tubes are disposed at an incline so as to form the left hand wall of the hopper bottom 70, as it is indicated in Fig. 1.

Preferably the intermediate primary superheater section including the wall tubes 64 extends entirely across the front wall of the unit. In other words, this component of the primary superheater receives radiantly transmitted heat from both furnaces. With this arrangement, of course, the headers 62, 66 and 68 extend entirely across the unit.

Other heat absorptive surfaces for the reheater furnace 22 involve reheater tubes along that portion of the wall 12 adjacent the reheater furnace. These reheater tubes are indicated at 74 in Figs. 2, 3, and 4. They lead upwardly from the lower header 76 which preferably receives exhaust steam from a high pressure or intermediate turbine stage. Steam reheated by these tubes flows upwardly to the header 78, from which it is conducted by appropriate circulators 80 to the intermediate reheater header 82. From this header the steam flows to the serially connected tube sections forming the banks of tubes 86—89 (Fig. 2) of the reheater component 84, to the reheater outlet header 90 from which the reheated steam flows through a conduit 92 to the inlet of another turbine stage.

The rear wall of the reheater furnace 22 includes tubes or tubular steam generating sections similar to those indicated at 50, 52, and 54, described with reference to the superheater furnace.

The last section of the reheater 84 described above may take the form of the widely spaced platens 86', 88', and 89' as indicated in Fig. 3 of the drawings, the rows of platens 88' and 89' being disposed in a furnace outlet or horizontal gas pass 100 at the top of the unit. This gas pass is similar to the superheater gas pass 102 of Fig. 1.

Tracing the flow of steam from the steam and water drum 44 through the several components of the superheater indicated in Fig. 1, the steam first flows from the drum 44 through a plurality of circulators 104 to upper side wall headers 106 at the top of the downflow of gas pass 108, it being understood that there is such a header at each side wall of this gas pass. From these headers the steam flows downwardly through the side wall tubes 110, exposed to the hot gases within the gas pass. From these tubes the steam flows into the side wall header sections 112 and thence to the header section 114 along the rear wall 16 of the unit. Thence, the steam flows upwardly through a row of wall tubes 116 along the rear

wall 16 of the gas pass and then through the roof tube sections 118 to the header 120. Other tubes conduct steam from the header 114 across the lower part of the gas pass as indicated at 118, thence upwardly through the sections 121 along the wall 122, and then through the screen tube sections 124 to the header 120. From this header the steam flows through appropriate conduits or circulators 126 to the inlet header 62 for one of the intermediate sections of the primary superheater. From the outlet header 66 of this primary superheater section steam flows through a plurality of circulators 130 to the inlet header 132 for the intermediate convection section 134 (Fig. 1) of the primary superheater, this intermediate convection section being disposed at the rear of the furnace outlet or horizontal gas pass 102.

From the second intermediate primary superheater section 134 the steam flows to the header 136, and thence through one or more conduits 138 to the inlet header 140 of the secondary or high temperature superheater component indicated, in its entirety, at 142. This superheater component consists of a plurality of serially connected tubes forming the widely spaced platens 142' (see Fig. 3), the more narrowly spaced platens 142'', and the still more narrowly spaced and smaller platens 142'''. From the secondary superheater component 142 superheated steam flows to a header 144, and thence through a conduit 146 to the inlet of a steam turbine, or other point of use. The conduits 138 preferably lead through an interstage spray attenuator.

The gas flows from the superheater furnace 24 and the reheater furnace 22 are separated by the division wall component and by other wall components, such as 160 and 162 (Fig. 3), with the wall 162 preferably extending through the gas turning space at the top of the downflow gas pass and continuing downwardly between the sections of the banks of tubes 164 and 166 of the economizer. These economizer banks of tubes are formed by series connected return bend tubular sections conducting water from the economizer inlet header 168 to the economizer outlet header 170, whence the water flows by appropriate conduits to the steam and water drum 44. The gas pass wall 162 is continued down to the proportioning dampers 172, there being differentially operable sets of these dampers at the outlets of the separate gas passes.

As indicated in Fig. 4 of the drawings, the steam generating wall tubes 46 are connected at their upper ends to the wall tube header 180, from which appropriate connections 182 lead to the drum 44, it being understood that the wall tubes 46 are suitably connected into the circulation of the unit by a lower wall tube header and appropriate circulatory connections, as well understood in this art.

It is also to be understood that the various walls of the pertinent unit fare thermally protected by heat insulating material, as would also be involved in the roof 190 and its associated wall portions including the wall sections 192 and 194 around the drum 44. Such material would also be included in the sections 196, 198 and 200 forming the windbox for the secondary air which is provided for the burners 26 to 29 in a manner well understood in the art.

Although the invention has been described with reference to a preferred embodiment illustrated in the drawings, it is to be understood that the invention is not limited to all of the details of this embodiment. The invention is rather to be considered as of a scope, commensurate with the scope of the sub-joined claims.

What is claimed is:

1. A high capacity high pressure steam generating, superheating and reheating unit comprising front, rear and opposite side walls forming a vertically elongated setting of rectangular cross-section, division wall means including a row of vertical steam generating tubes arranged to divide said setting into side-by-side superheater and reheater furnace chambers each having a heating gas pass opening through the rear wall thereof, burner means in said front wall arranged for independently firing said superheater and reheater furnace chambers, a high temperature steam superheating system comprising a radiantly heated primary superheater section formed by tubes lining the front walls of said superheater and reheater furnace chambers, and a secondary superheater section formed by transversely spaced radiant and convection heated vertical tube platens at the entrance to said superheater furnace heating gas pass, and a high temperature steam reheating system comprising a radiantly heated primary reheater section formed by vertically extending tubes lining the side wall of said reheater furnace chamber opposite said division wall means, and a secondary reheater section serially connected to said primary reheater section and formed by transversely spaced radiant and convection heated vertical tube platens at the entrance to said reheater furnace heating gas pass.

2. A high capacity high pressure steam generating, superheating and reheating unit comprising front, rear and opposite side walls forming a vertically elongated setting of rectangular cross-section, division wall means including a row of vertical steam generating tubes arranged to divide said setting into side-by-side superheater and reheater furnace chambers each having a heating gas pass opening through the rear wall thereof, burner means in said front wall arranged for independently firing said superheater and reheater furnace chambers, a high temperature steam superheating system comprising a radiantly heated primary superheater section formed by tubes lining the front walls of said superheater and reheater furnace chambers, a second convection heated primary superheater section serially connected to said first primary superheater section and formed by tube banks extending across the heating gas passes from both said superheater and reheater furnace chambers, and a secondary superheater section formed by transversely spaced radiant and convection heated vertical tube platens at the entrance to said superheater furnace heating gas pass, and a high temperature steam reheating system comprising a radiantly heated primary reheater section formed by vertically extending tubes lining the side wall of said reheater furnace chamber opposite said division wall means, and a secondary reheater section serially connected to said primary reheater section and formed by transversely spaced radiant and convection heated vertical tube platens at the entrance to said reheater furnace heating gas pass and upstream relative to the primary convection heated steam superheater section in said heating gas pass.

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