METHOD OF VAPOR GENERATION, SUPERHEATING AND REHEATING, AND MULTIPLE FURNACE APPARATUS THEREFOR INCLUDING GAS RECIRCULATION

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This invention relates in general to a method of and apparatus for generating vapor and heating the vapor to a high temperature over a wide load range, both on generation and also on its return for reheating from an intermediate stage of an associated multi-stage vapor turbine. More specifically, the invention relates to a method of the arrangement of the character described in which steam generated at high pressures is superheated and reheated to high temperatures by means of two separately fired and controlled furnaces discharging separate streams of heating gases, with the steam to be reheated receiving heat by convection from only one of said heating gas streams and the steam to be superheated receiving heat by convection from both of said heating gas streams. A further specific object is the provision of a steam superheating and reheating method and apparatus of the character described in which the high steam superheated and reheated temperatures can be maintained over a wide range of loads by a construction of the separate associated furnaces in a manner to vary the radiant heat absorption of the furnace walls and thereby the heat content of the heating gas streams contacting the superheating and reheating surfaces. A still further object is an improved arrangement of steam superheating surface in the steam reheater section of a steam generating unit of the character described which permits the reheater surface to be constructed and arranged for a low steam pressure drop through the reheater and relatively low maximum tube metal temperatures, while providing an efficient absorption of heat from the high temperature heating gases leaving the reheater and protecting the reheater during the periods of low or no steam flow therethrough.

In steam generators including convection superheating and reheating units, both the superheated steam temperature and the reheated steam temperature drop as the load is reduced if no corrective steps such as gas bypassing, steam attemperating or gas recirculation, are taken. The reheated temperature drops at a greater rate than the high pressure superheater temperature, inasmuch as the superheating takes place from a substantially constant saturated temperature of the high pressure steam while the reheating is from the temperature of the low pressure steam which decreases as the steam flow to and through the compound steam turbine is reduced.

For highest thermo-economic efficiency of such a steam turbine it is not only desirable to maintain the superheated steam supplied at a substantially uniform temperature but it is also desirable to provide the reheated low pressure steam at a uniform temperature irrespective of steam flow.

In order to provide uniformity of steam temperatures of both the high pressure superheated steam and the low pressure reheated steam, it is necessary to provide for a greater correction adjustment, as regards degrees, in the reheated steam than in the superheated steam. It is the aim of the present invention to provide apparatus and a method of control which will effect a substantially uniform temperature of superheated and reheated steam delivery over a wide range of steam generator output.

In the present invention two steam heating surfaces served by an auxiliary furnace are arranged so that all of the gases therefrom first pass over steam reheating surface and then over steam superheating surface. This is advantageous in a unit where both the high pressure steam and the low pressure steam are to be heated to a high temperature, thus requiring a high percentage of the heat absorbed in the unit to be used for the heating of steam as compared with that required for steam generation.

By having the reheater surface and superheater surface arranged for sequential heating gas flow, the high temperature gases from the auxiliary furnace are first utilized in effecting the required high degree of heating of the low pressure steam before they are utilized for superheating of the high pressure steam.

In the present invention, the main furnace is vertically elongated with its gas outlet to convey the heating surface to the side and at the upper portion thereof, while the auxiliary furnace is located alongside the main furnace below the aforesaid convection surface and its gases are passed over steam reheating and superheating surfaces and then into the main furnace at the same side at which the main furnace has its gas outlet.

In one of its more specific aspects, the invention involves a water tube steam generator having a plurality of separately fired furnaces, with one of the furnaces being fired or controlled from the standpoint of reheater control, and another being fired from the standpoint of superheater control. In this specific installation the gases flow from one furnace through a convection pass around the tubular elements of a steam reheater and then a steam superheater and then join the gases from the other furnace. Beyond this junction of the gases the combined gases pass through another convection pass disposed above the reheater gas pass. In this upper pass there are disposed the tubular elements of a convection or finishing superheater, some of which extend across the gas inlet end of the upper convection pass and also across the gas outlet end of the lower convection pass. In the preferred embodiments of the invention a convection low pressure reheater received heating gases directly from its own separately fired furnace, with part of the high temperature portion of the associated high pressure steam superheater positioned directly downstream thereof to receive the full flow of heating gases immediately subsequent to their passage over the reheater. By such an arrangement, the heat input into the reheater may be effectively regulated by varying the heat content of the gases flowing thereto, while the greater heat absorption capabilities of the high pressure steam flow through the superheater, because of its greater quantity, higher specific heat, higher density, and greater permissible pressure drop, assured the desired reduction in gas temperature with an economic amount of superheating and reheating surfaces, and with a low steam pressure loss through the reheater. The presence of secondary superheater surface in this location thus enables the desired final superheat temperature to be more easily attained.

Inasmuch as the heat release in, and heat characteristics of the gases flowing from, the reheater furnace are regulated primarily in accordance with reheated steam requirements, the quantity of heat released would be inadequate to fully accomplish the required steam generation and steam superheating of the unit. A main feature of the invention with separate regulable firing means is utilized for the release of such additional heat for radiant heat absorption to water tubes in the furnace walls to provide addi-
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ional steam to meet the load demand, and to supply additional heat for superheating the steam generated in the main auxiliary furnace wall tubes as delivered from a common steam and water drum.

The invention also includes a method of controllably varying the firing rates of the separate furnaces to promote the maintenance of optimum steam temperatures at different steam requirements, the rate of firing being controlled for the desired load to effect desired reheat and/or superheat temperatures in the operation of the pertinent steam generator. One such method includes the automatic control of the firing rate of the superheater furnace from variations in final steam pressure, and the control of the firing of the reheater furnace in response to changes in the reheater steam outlet temperature. This method may also involve the recirculation of gases to the superheater furnace in response to changes in the superheater steam outlet temperature to maintain superheat over a wide load range.

The invention also includes a similar method in which gas is recirculated to both furnaces. In such method, the firing rates of the burners are coordinated with, or controlled from, steam pressure, as an indication of steam demand, while the amount of gas recirculated to the superheater furnace is controlled by variations in superheated steam outlet temperature and the amount of gas recirculated to the reheater furnace is controlled in accord with the variations in reheater steam outlet temperature.

Preferred embodiments of the invention are indicated in the accompanying drawings, in which

Fig. 1 is a vertical section disclosing the multiple furnaces, the reheater and the superheater, with some of the tubes of the latter extending through walls of the convection passes for the reheater and the superheater;

Fig. 2 is a partial horizontal section on the line 2—2 of Fig. 1;

Fig. 3 is a partial horizontal section through the convection pass for the reheater, taken on the line 3—3 of Fig. 1;

Fig. 4 is a partial horizontal section through the divided furnace construction, on the line 4—4 of Fig. 1;

Fig. 5 is a diagrammatic view of a modified steam generating installation with the furnace and related parts shown mainly in vertical section; and

Fig. 6 is a diagrammatic view of a further modification of the Fig. 5 installation, showing a modified control system for the furnace firing means, and the gas re-circulation system for control of both steam, superheat and reheat temperatures.

The steam generating installation shown in Fig. 1 of the drawings includes two furnaces, 10 and 12, the latter being fired by burners 14 and 16 at varying rates dependent upon the requirements of the reheater 16 disposed in the convection pass which affords a gas outlet for the furnace 12. The gases from the outlet of the furnace pass across the reheater in the directions of the arrows 29—22 to a point where they join the gases from the furnace 10, which is independently fired by burners such as those indicated at 24 and 26.

Beyond the junction zone 28 of the gases from the separated furnaces 10 and 12, the gases pass upwardly to a position forwardly of an upper convection pass in which the two sections 30 and 32 of the convection superheater are disposed. The gases passing upwardly from the zone 28 turn in the gas chamber 34 forwardly of the superheater and pass generally horizontally in the general direction of the arrow 36 across the tubular elements of the superheater sections to a duct 38 or other means which conduct the gases to an economizer, and air heater, and thence to an exhaust flue or stack.

The steam generating tubes defining the walls of each furnace have their upper ends connected to the steam and water separating drum 40. The steam separated in the drum 40 passes through the connectors 42 to a superheater inlet header 44 from which the flow continues through the connected return bend tubes of the superheater section 30 to the intermediate superheater header 46.

Between the outlet header 46 and the inlet header 50 of secondary superheater section 32, a spray atomizer 47 is connected by suitable pipes as shown. The secondary superheater section 32 consists of serially connected return bend tubular elements arranged as an upright bank across the gas pass 36, the elements being connected to outlet header 52. Superheated high pressure steam is delivered from this header to a steam turbine or other point of use.

Steam which has been expanded to a lower pressure in the turbine is returned to the unit for reheating to a higher temperature. The lower pressure and lower temperature steam is conducted to the reheater inlet header 54, which is disposed between the lower part of the inclined wall 56 of the upper convection pass and the upper wall 58 of the lower convection pass for the reheater. From the reheater header 54 steam flows through serially connected return bend tube reheater sections 62 and 60 to a reheater outlet header 64, from which the steam may be returned to the inlet of a low pressure turbine (or low pressure turbine stage) for further expansion therein.

The illustrative steam generator has a double hopper bottom. One wall of each hopper consists of 4" tubes on 6" centers with space closures between the tubes. These tubes in the walls of the hoppers 70 and 72 are connected to lower headers 75 and 76, while the tubes of the other hopper walls are connected to headers 74 and 77. Appropriate water supply downcomer connections (not shown) connect the water space of the drum 40 and headers 74—77. The tubes for the inclined surfaces of the first mentioned hopper bottoms are swaged down at the upper edges of the hoppers for connection with wall tubes, such as those indicated at 81 and 82, the tubes being bare on their furnace sides with their walls directly exposed to the combustion elements within the furnace. The tubes 83 and 85 define the walls 71 and 73 and the side walls of the furnaces are defined by steam generating wall tubes connected through headers such as 86, 90 and 89, and other appropriate connections, into the circulation system. The side walls of the upper convection pass in which the superheater sections 30 and 32 are located, are defined in part by tubes, such as those indicated at 86. They are bare tubes with their lower ends connected to the header 90 and their upper ends connected to the upper side wall headers 92 which are directly connected to the steam and water drum 40 by appropriate tubular connections. Some of the tubes 83 have intermediate sections arranged transversely of the installation and defining the roof 58, or upper wall of the transverse convection pass in which the reheater sections 60 and 62 are disposed. This roof or wall extends to a position near the front wall 87 and then the tubes defining the roof are bent, as indicated at 89 so that they continue rearwardly in an upwardly inclined position as indicated at 91 to define the wall 56, or bottom of the upper convection pass. Rearward of this pass these tubes continue as staggered and more widely spaced sections 100 and 102 to a header 102 from which roof tubes 103 lead to the drum 40. The remainder of the tubes 83 have their upper ends connected to header 102. The roof tubes over the convection pass for the superheater sections 30 and 32 extend from header 102 to drum 40 and are combined with refractory and insulating material to form a gas tight roof structure. Similar materials are also involved in the furnace walls and other boundaries of the unit.

The tubes such as 81 and 82 of the division wall separating the furnaces 10 and 12 have intermediate and oppositely inclined tubular sections of larger diameter, such as indicated at 110 and 112. These sections are arranged in wall formation to provide, with space closures and suitable heat resisting material, the inter-
mediate walls or roof portions 114 and 116. They con-
tinue from the arch noses 118 and 120 through the
ward inclined sections 122 and 124 to define, with
suitable space closures, the walls forming the lower
boundary for the forwardly extending convection pass
in which the re heater sections 60 and 62 are disposed
on opposite sides of the spx or upper junction point 130.
The flow through these tubes continues through con-
ected tube sections 132 and 134 to a header 136 which
is connected to riser tubes 140 extending through the
wall 56 and then through the roof of the installation
rearwardly of the superheater section 32. Thence the
circulatory flow continues through the connected tubular
connections 142 to drum 40.

The illustrative installation is top supported with the
pressure parts supported from steel work such as that
indicated at 150. The pressure parts including the head-
ters and tubes are supported from the steel work by
hangers such as those indicated at 152—155. Other ap-
propriate steel work and hangers are indicated for sup-
porting the pressure parts at a position above the roof
58 of the lower convection pass, and in the space just
below the floor of the same pass.

In the operation of the apparatus shown by Fig. 1, the
unit was brought into service and brought up to the desired
operating pressure by firing substantially all of the fuel
into furnace 10 by means of burners 24 or 26, so that
during the period when no steam is flowing through the
re heater, there will be a minimum of heat imposed upon
the tubes of the re heater (60 and 62). Tube lengths of
the secondary superheater through which high pressure
steam flows before steam flows through the re heater
5 tubes, offer protection from the overheating of the re-
heater tubes by the gases originating from burners 24 or
26, during the starting period.

After the turbine (associated with the unit) is started,
steam from an intermediate pressure stage will flow to
the re heater inlet header 54 and will be delivered from
the re heater to the inlet of the low pressure turbine for
further expansion. When this steam flow is established,
burners 14 or 16 will be fired to provide a flow of heating
gases to the re heater so that the re heated steam will be
delivered to the turbine at the desired temperature.

The rate of fuel burning in burners 14 and 16 is
adjusted to maintain the re heater temperature at the desired
value, while the burners 24 to 26 effect fuel burning in
furnace 10.

The gases leaving the re heater pass join the products
of combustion from furnace 10 so that the gas flow
through the super heater pass is the sum of the gas flows
of both furnaces 10 and 12. As the gases from both
furnaces flow over the super heater, the temperature of
steam would be too high in the maximum load range,
and the interstage spray atomizer 47 is therefore used
to reduce the outlet temperature to the desired degree,
under such conditions.

In the modification shown in Fig. 5 of the drawings,
the arrangement of the furnaces 160 and 162, re heater
sections 166 and 170, and superheater sections 164 and 182
is similar to that of the corresponding elements in the Fig. 1
unit. The boundary surfaces of the furnaces as the
walls 168 and 170 are defined, in part, by steam gen-
rating tubes having their upper ends connected to the
steam and water drum 171 from which steam passes
to the super heater inlet header 174. From this header steam passes through the secondary superheater section 164 of the superheater to the intermediate header 176
from which the steam passes through a spray atomizer
178 to an inlet header 180 for the secondary superheater section 182 to which extend
the tubes 182a of which extend
along the re heater gas pass 184. The outlet header of
the superheater is indicated at 188.

The furnace 160 is shown as fired by pulverized fuel
burners 190 and 192 which receive pulverized fuel through the tubular connections 193 and 194 from a pul-
verizer 196. The amount of fuel supplied by the pul-
verizer 196 to the burners 190 and 192, and hence the
rate of firing of the burners, is controlled from steam pressure in the outlet header connection 197 which joins from the outlet header 188 of the superheater. Means diagrammatically shown for effecting such control includes the damper 200 and fan 202, the outlet of which is con-
ected to the pulverizer 196 to supply primary carrier
air thereto. The damper 200 is actuated by an operator
mechanism 204, connected by linkage 206 to the damper.
The operator 204 is actuated as a result of changes in
fluid pressure in line 208 caused by the effect of varia-
tions in steam pressure in the superheater outlet line 197
upon the pressure responsive element 210.

The re heater furnace 162 is fired by pulverized fuel
burners 212 and 214 supplied with primary air and fuel
by the lines 216 and 218 leading from the pulverizer 220.
The air flow to the pulverizer fan 222 (and air flow to
through the pulverizer) is controlled by a damper
224 in the inlet tube 226. To effect control of this dam-
per, it is connected to an operator 230 by linkage 252,
the operator 230 being actuated by changes in fluid pres-
sure in line 233 which connects with a fluid actuated
device 234 controlled in response to the variable effects
of temperature upon the temperature responsive element
236 of the latter is shown in the upper central part of
Fig. 5 as having its bulb 237 within the line 228 leading
from the outlet header of the re heater.

Gases from the furnace 162 pass over the surfaces of
the re heater 166 and adjacent portions 182a of the sec-
dary superheater tubes and then join the gases of the
furnace 160 to pass upwardly therein and then through
the super heater gas pass 186 to a gas turning space above
an economizer 240 which is illustrated as consisting of a
bank of tubes extending transversely of a gas pass hav-
ing the roof 242 and walls such as 246. The gases pass
downwardly over the economizer surfaces and then turn
somewhat in the direction indicated by the arrow 248 and
pass through the tubes of the air heater 250. The air
for supporting combustion passes in the direction of the
arrows 252 into the inlet 254 of the air heater and
then downwardly around the air heater tubes in and the
direction of the arrows 256 and 258 through the duct
work 260 to secondary air enclosures such as 262 about
the burners 190 and 192. A fan or blower supplies air to
the inlet 254.

For control of super heat at loads varying from a high
percentage of full load downwardly, furnace gases from
position below the air heater 250 pass through the duct
274, the fan 272, the duct 276, and then through the con-
ected duct 278. Recirculated gases passing through the
duct 278 enter the secondary air duct for the burners 190
and 192 at the position indicated at 282 when the pos-
tion of the damper 284 is such as to permit such action.
In the operation of the system shown, a minimum of gas
is recirculated at the predetermined percentage of full
load when the recirculating fan 272 begins to operate.
The amount of gas recirculated is increased as the load on
the unit decreases. The gas recirculation for the control
of furnace temperatures is effective upon burners 190
and 192. The rate of fuel burning is under the control
of steam pressure, while the amount of gas recirculated
to the burners is under the control of damper 284 which
is subject to the variation in temperature in the super-
heated steam outlet line 197 through the control elec-
tronics 295, 296, 304, 305, 306, 307, and 308, similar to
those above described.

In the Fig. 5 system the firing rates of the burners 190
and 192 for the superheater furnace 160 are controlled
by means responsive to steam pressure in the steam line
197.

The fuel delivery from pulverizer 220 to burners 212
and 214 of the re heater furnace 162 is regulated in ac-
cordance with steam load and the temperature of the
reheated steam delivered through pipe 228. A control
pressure, based on high pressure steam delivery, from control element 211 is transmitted through lines 208 and 416 to the relay indicated diagrammatically at 420. A control pressure varying with the temperature of the re-heated low pressure steam is transmitted from element 234 through line 430 to relay 420. Relay 420 combines the two control pressures and transmits a resultant control pressure through line 233 to damper operator 230. Thus the firing of furnace 162 is subject to two element control, namely from the steam load from the unit, as determined by variation in the pressure of the high pressure steam, and secondly by the temperature of the re-heated low pressure steam.

This two element control stabilizes the operation of the reheat furnace as regards the degree of steam reheating and steam generation by that furnace, preventing the fuel delivery from pulverizer 230 from drifting too far out of line with the fuel delivery from pulverizer 196 firing the main furnace 160. This two element arrangement of pressure and temperature control for the reheat furnace provides a stabilizing effect on the steam temperature and on the amount of steam generated in the reheat furnace.

A spray atomizer 178 is arranged between the sections of the high pressure steam superheater, to effect a limiting control on the temperature at which the superheated steam will be delivered when temperature of the gases leaving the furnace 160, through the high load range, are such that an excessive amount of superheating heat absorption takes place, requiring a reduction in the heat of superheat.

The system shown in Fig. 6 of the drawings is similar to that shown in Fig. 5. One difference, however, is that provision is made for gas recirculation to each one of the furnaces 160 and 162, the gas recirculation duct 273 having a branch 280 through which flue gases are controllably admitted through the outlet 290 to the secondary air stream to the burners 214 (below horizontal partition 213). This flow is controlled by a damper 294 which is positioned by steam temperature as determined from measurement of temperature of the re-heated steam in pipe 220 by temperature responsive element 320, modified by variation in steam flow of high pressure superheated steam. The variation in steam flow is determined by meter 405 associated with orifice 404 in steam line 197. Variations in steam flow vary a loading pressure in line 407, which is transmitted to relay 402. Relay 402 combines the loading pressure resulting from temperature measuring element 320 and loading element 316, with the loading pressure from 407, and the resultant loading pressure is transmitted through line 314 to the damper operating device 312. Another difference is that the firing rates of the pulverizers 196 and 220 are regulated directly by control elements 210, 412, 414, 208, 204, 206, 208, 416, 220, and 232, responsive to high steam pressure in the superheated steam line 197.

The control of gas recirculation to the main furnace 160 is through means responsive to steam temperature as modified by means responsive to steam flow in the high pressure steam line 197. The flow of recirculated gas to the reheater or auxiliary furnace 162 is regulated from re-heated steam temperature and is operatively effective through control elements 316, 318, 320, 400, 402, 314, 312, and 310, as modified by means responsive to high pressure steam flow in the line 197 (control elements 404—407, 402, 314, 312, and 310). It will be appreciated that the above described control apparatus involves arrangements by which a multiple furnace unit of this type shown may be advantageously operated in any of the following manners:

(a) The reheater furnace may be operated in accordance with indications of reheat steam temperature by regulation of fuel introduction, while the main furnace may be operated in accordance with steam load on the unit.

(b) The operation of the reheater furnace may be in accordance with the above, with the fuel introduction into the main furnace in accordance with load on the unit, but with regulation of the temperature of the superheated high pressure steam from the unit being effected by gas recirculation to the main furnace.

(c) The fuel firing of the main and reheater furnaces may be regulated in accordance with steam load on the unit, with selective gas recirculation to the reheater furnace to regulate the temperature of the delivered re-heated low pressure steam, and with gas recirculation to the main furnace to effect control of the temperature of the high pressure superheated steam.

(d) Still another method is possible with the arrangement of Fig. 6, that is to regulate the fuel delivery to both furnaces in accordance with load, and to use gas recirculation on the reheater furnace only.

In each of the steam generating units shown by Figs. 1, 5 and 6, the gases in the reheater gas pass over rows of secondary superheater tubes 63 or 182 immediately succeeding the reheater surfaces in a gas flow sense. These superheater tubes form extensions of the corresponding auxiliary furnace.

Rows of superheater tubes within the superheater gas pass. The disposition of superheater tubes immediately downstream of the reheater and in the same gas pass enhances the efficiency of high temperature and high pressure steam generating units by effectively absorbing high temperature heat without substantially changing the desired ratio of heat absorbed by steam heating to the heat absorbed in steam generation over the normal operating range of the unit. The steam passing through the superheater tubes in the reheater pass is subject to further heating in the superheater pass. The convection reheating effect is thus accomplished solely by the stream of heating gases from the auxiliary furnace, while the convection superheating effect is accomplished partly by heating gases from both the main and auxiliary furnaces, with an intermediate portion of the convection superheating effect secured solely by gases from the auxiliary furnace.

While in accordance with the provisions of the statutes we have illustrated and described herein the best forms of our invention now known to us, 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 our claims, and that certain features of our invention may sometimes be used to advantage without a corresponding use of other features.

This application is a continuation of our prior application, Serial Number 193,852, filed November 3, 1930, now abandoned.

What is claimed is:

1. In a steam generating and superheating unit, first and second vertically extending contiguous fuel fired furnaces, upwardly extending rows of steam generating tubes along the outside walls of said furnaces, a dividing wall between said furnaces including a row of upright steam generating tubes, some of said generating tubes delineating the roof of the first furnace, upper extensions of said last mentioned tubes being spaced apart and so arranged relative to the roof of the first furnace as to form therein with a gas outlet passage leading from the first furnace into the second furnace at a position intermediate the height of the second furnace, a convection steam reheater.
positioned across gas flow in said gas outlet passage from the first furnace, means forming a gas outlet passage leading from the second furnace and positioned at an elevation higher than the outlet of the first furnace, a superheater in the gas outlet passage from the second furnace, and means controllably recirculating furnace gases from a position downstream of the superheating zone directly to either one or both of said furnaces to regulate either or both superheating and reheating.

2. In a multiple furnace steam generating and reheating unit, first and second vertically elongated furnaces having upright steam generating tubes in their outside walls, a division wall common to the two furnaces and including a row of upright steam generating tubes, some of said steam generating tubes having extensions defining the roof of the second furnace, upper parts of the division wall tubes being bent out of their wall defining plane to coact with the roof of the second furnace to provide a lateral reheater gas passage through which the gases from the second furnace join the gases of the first furnace at a position intermediate the height of the unit, means including the upper parts of some of said steam generating tubes and forming a lateral gas passage extending over the roof of the second furnace and acting as an outlet for the gases from both furnaces, means for separately firing the furnaces, a convection reheater including pendent tubes disposed within the first of such gas passages, a convection superheater including pendent tubes disposed across the gas flow in the second gas passage, the gas flow and gas temperature conditions of the first furnace being controlled to maintain a predetermined reheater temperature, and the gas flow and gas temperature conditions in the first furnace being controlled to maintain a predetermined superheat temperature.

3. In a multiple furnace steam generating and reheating unit, first and second vertically elongated furnaces having upright steam generating tubes in their outside walls, a division wall common to the two furnaces and including a row of upright steam generating tubes, some of said steam generating tubes having extensions defining the roof of the second furnace, upper parts of the division wall tubes being bent out of their wall defining plane to coact with the roof of the second furnace to provide a lateral gas passage through which the gases of the second furnace join the gases of the first furnace at a position intermediate the height of the unit, means including the upper parts of some of said steam generating tubes and forming a lateral gas passage extending over the roof of the second furnace and acting as an outlet for the gases from both furnaces, means for separately firing the furnaces, a convection reheater including pendent tubes disposed within the first of such gas passages, a convection superheater having a majority of its pendent tubes disposed within the second gas passage and the remainder of its pendent tubes extending across the gas flow in both of said gas passages.

4. In a multiple furnace steam generating and reheating unit, first and second vertically elongated furnaces having upright steam generating tubes in their outside walls, a division wall common to the two furnaces and including a row of upright steam generating tubes, some of said steam generating tubes having extensions defining the roof of the second furnace, upper parts of the division wall tubes being bent out of their wall defining planes to coact with the roof of the second furnace to provide a lateral gas passage through which the gases of the second furnace join the gases of the first furnace at a position intermediate the height of the unit, means including the upper parts of some of said steam generating tubes and forming a lateral gas passage extending over the roof of the second furnace and acting as an outlet for the gases from both furnaces, means for separately firing the furnaces, a convection reheater including pendent tubes disposed within the first of such gas passages, a convection superheater having a majority of its pendent tubes disposed within the second gas passage and the remainder of its pendent tubes extending across the gas flow in both of said gas passages.

5. In a steam generating unit, separately fired reheater and superheater furnaces each having steam generating tubes along its walls, means forming a reheater gas passage leading from the reheater furnace into communication with the flow of gases originating in the firing means of the superheater furnace, means forming a superheater gas passage disposed adjacent to the reheater gas passage and leading from the reheater furnace, a convection reheater disposed in the superheater gas passage and a convection reheater disposed in the reheater gas passage, said last named means combining with a wall of the superheater furnace to form a restricted gas mixing throat intermediate the height of the superheater furnace and between the outlet of the reheater gas passage and the inlet of the superheater gas passage.

6. Apparatus for generating, superheating and reheating steam comprising two separate steam generating furnace sections having tubular water wall linings arranged to be subject to radiant heat, means for independently firing fuel in each of said furnace sections to produce a stream of heating gas therein, means forming two gas off-take passages each opening from the upper portion of one of said furnace sections, a group of steam superheater tubes arranged in one of said gas off-take passages, a group of steam reheater tubes arranged in the entrance portion of the other gas off-take passage and extending over substantially the entire cross-sectional flow area thereof, and a group of steam superheater tubes in said other gas off-take passage wholly at the downstream side of said steam reheater tubes relative to the heating gas flow thereacross so that all of the heating gas flowing through said other gas off-take passage flow first over the reheater and then over the superheater therein, said last named group of steam superheater tubes having a steam flow connection with said steam superheater tubes in said first gas off-take passage.

7. The method of generating, superheating and reheating steam in a steam generating and reheating unit, the method comprising the steps of separately burning fuel in two laterally adjacent separate furnaces to produce two separate streams of high temperature heating gases so confined that the streams of heating gas generated in the respective furnaces are out of contact with each other while in the furnaces, separately flowing each of said streams upwardly in radiant heat exchange relationship with enclosed water streams in the corresponding furnaces, thereafter flowing one of said heating gas streams in convection heat exchange relationship with enclosed streams of high pressure steam to superheat the same, flowing all of the second of said heating gas streams in convection heat exchange relationship with enclosed streams of low pressure steam for reheating the same and then while still separate from said first heating gas stream in convection heat exchange relationship with enclosed streams of high pressure steam for superheating, increasing and decreasing the rate of fuel firing in said furnaces in accordance with an increase and decrease respectively.
in the heat demands of said unit, and varying the radiant heat absorption of the enclosed water streams in each of said furnaces independently of the rate of fuel firing therein in response to variations in the final temperature of the superheated steam and the final temperature of the reheated steam, respectively, by varying the radiation effect of the heating gases in each of said furnaces on the enclosed water streams therein.

8. Apparatus for generating, superheating and reheating steam comprising two separate steam generating furnace sections having tubular water wall linings arranged to be subject to radiant heat, means for independently firing fuel in each of said furnace sections to produce a stream of heating gas therein, means forming a gas offtake passage opening from the upper portion of each of said furnace sections, a group of steam superheater tubes arranged in one of said gas offtake passages, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof, a group of steam superheater tubes in said other gas offtake passage, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof, a group of steam superheater tubes in said other gas offtake passage, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof, a group of steam superheater tubes in said other gas offtake passage, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof, a group of steam superheater tubes in said other gas offtake passage, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof, a group of steam superheater tubes in said other gas offtake passage.

9. Apparatus for generating, superheating and reheating steam comprising two separate steam generating furnace sections having steam generating tubular water wall linings arranged to be subject to radiant heat, means for independently firing fuel in each of said furnace sections to produce a stream of heating gas therein, means forming a gas offtake passage opening from the upper portion of each of said furnace sections, a group of steam superheater tubes arranged in one of said gas offtake passages, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof, a group of steam superheater tubes in said other gas offtake passage, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof, a group of steam superheater tubes in said other gas offtake 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said other gas offtake passage, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof, a group of steam superheater tubes in said other gas offtake passage, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof, a group of steam superheater tubes in said other gas offtake passage, a group of steam reheater tubes arranged in the gas entrance portion of the other gas offtake passage and extending over substantially the entire cross-sectional flow area thereof.

References Cited in the file of this patent

UNITED STATES PATENTS
2,420,647 Boland ------------------ May 20, 1947
2,590,712 Lacerenza ------------------ Mar. 25, 1952

FOREIGN PATENTS
523,871 Great Britain ------------------ July 24, 1940