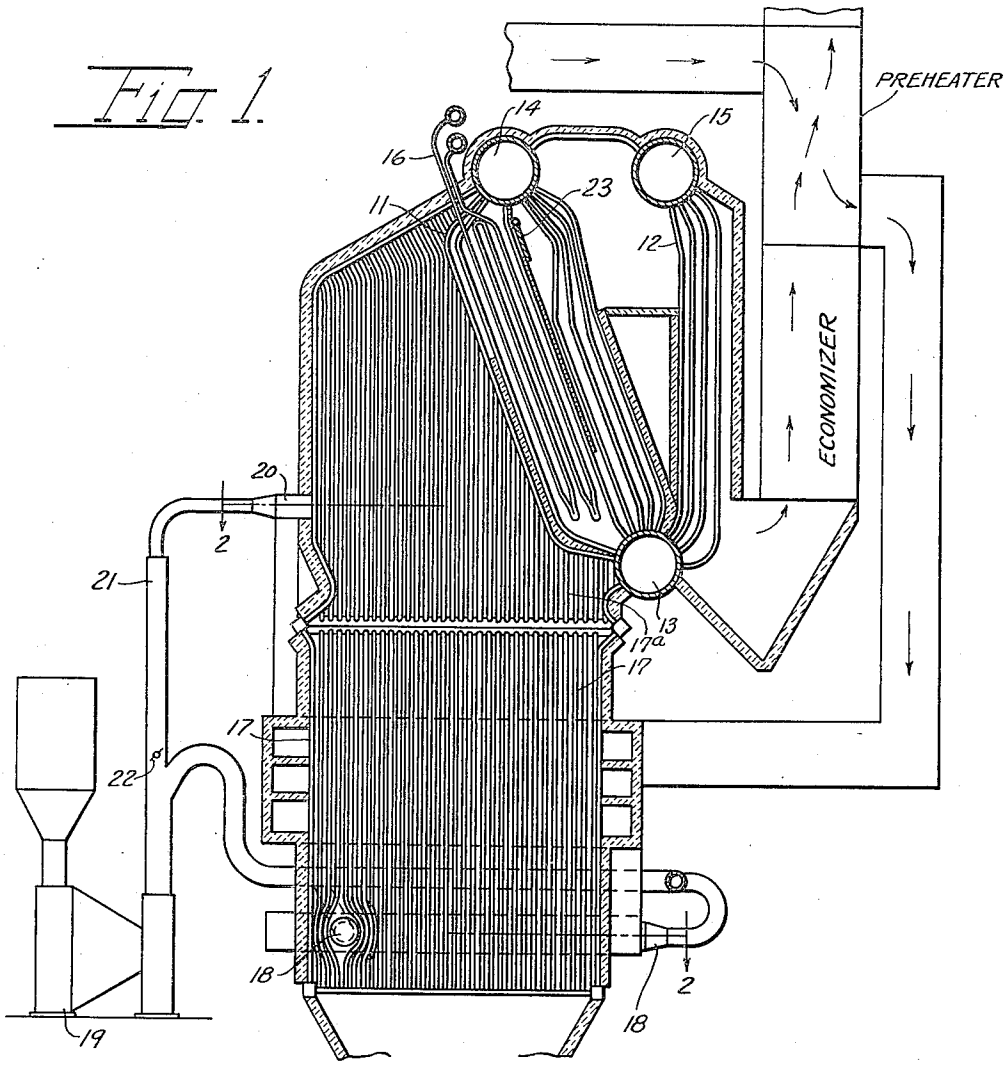
Nov. 23, 1937. G. P. JACKSON 2,100,190

METHOD OF CONTROLLING SUPERHEAT TEMPERATURE

Filed March 2, 1937

Fig. 1.



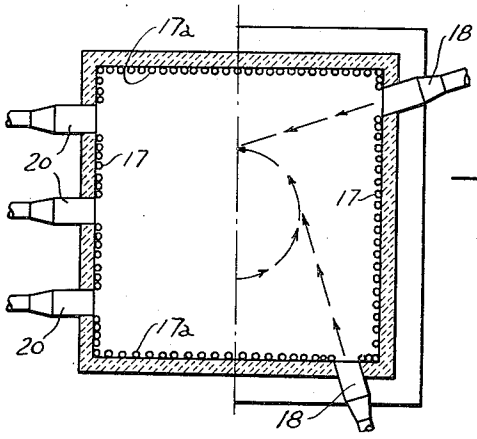


Fig. 2.

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METHOD OF CONTROLLING SUPERHEAT TEMPERATURE

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11 Claims. (Cl. 122—459)

The present invention relates to an improved method of controlling the temperature of superheated steam particularly in boilers provided with superheaters of the convection type.

Present day commercial requirements demand boilers capable of generating large quantities of steam and superheating it to high temperatures. Various arrangements have been proposed to provide sufficient volumes of gases for generating and superheating steam at both high and low loads in a boiler. One such arrangements is shown in Bennis Patent 1,580,776, issued April 13, 1926, wherein burners supplying fuel near the upper portion of a furnace chamber operate in conjunction with a stoker in the lower portion of the furnace. In the boiler of Gordon Patent 1,896,233, issued February 7, 1933, the major portion of the fuel is introduced from the top of the furnace and because the flames are directed downwardly he also provides auxiliary burners to heat wall tubes which otherwise would not receive their share of heat due to the path of travel of the main flame. Yarrow, 1,625,759 of April 19, 1927, shows an arrangement in which auxiliary burners are provided for heating the superheater, the gases from these burners, and part of the main stream of gases, being controlled by a damper when the auxiliary burners are operated at a constant rate, or both the damper and auxiliary burner regulation being interdependently varied for purposes of regulation. However, in all these arrangements the auxiliary burners, or the like, are provided for producing greater volumes of heating gases at high loads, the rate of fuel supply being increased with rise in steam demand and being decreased as the steam demand falls; that is, as the load rises the auxiliary firing means are brought into operation or the rate of firing is increased and vice versa.

In the operation of boilers having convection type superheaters the temperature of the superheated steam tends to rise with increases in steam demand. This condition is brought about as a consequence of the flow of increased quantities of steam through the superheater together with increased volumes of gases at hotter temperatures which yield proportionally less heat to generating surfaces in advance of the superheater than at low boiler loads, thus causing relatively hotter gases in larger volume to contact the superheater.

It is desirable to maintain a substantially constant degree of superheat over a wide range of boiler loads but, where a boiler is designed to provide the desired superheated steam temperate at high loads, the superheat is found to be too low at intermediate and low rates of steam demand, while arrangements providing the desired temperature at intermediate loads produce too much superheat at high loads and too little at low loads, and those providing the required temperature at low loads result in excessive steam temperatures on both intermediate and high loads.

The object of the present invention is to provide a boiler and a method of operation assuring a substantially constant superheated steam temperature for a wide range of boiler loads as, for example, where the steam demand at high loads is double that at low loads or greater.

In carrying out the invention the furnace of a boiler is provided with two sets of fuel burners located respectively near its top and bottom. The gases from the two sets of burners pass over the main generating elements of the boiler and the superheating elements, both being located above a furnace of substantial height. The lower set of burners produce gases imparting some of their heat to generating elements on the walls of the furnace so that the gases from these burners are partially cooled before being passed over the main generating and superheating elements. The gases from the upper set of burners do not heat the generating elements on the furnace wall to a substantial extent but pass directly over the main generating and superheating elements.

One form of boiler adapted to carry out the method of the present invention is illustrated in the accompanying drawings, in which

Fig. 1 is a diagrammatical elevational view of a boiler provided with firing means adapted to be operated in accordance with the method of the present invention in order to maintain a substantially constant superheated steam temperature over a wide range of boiler loads.

Fig. 2 is a sectional view on the line 2—2 in Fig. 1.

Referring to Fig. 1, the boiler has a furnace chamber 10 of substantial height above which are located the main generating elements and the superheating elements. The main generating elements comprise two banks 11 and 12 of generating tubes connected between the lower or water drum 13 and the upper steam drums 14, 15. The superheating elements 16 are mounted within or between tube rows of the bank 11 and partially shielded by one or more of the outermost rows of tubes of the bank. The walls of the furnace chamber are provided with steam generating tubes 17 and similar tubes 17a extend

along the upper portion of the side walls of the boiler, all these tubes being connected into the boiler circulating system. Near the bottom of the furnace is a set of burners 18 supplied with pulverized coal (for example) by a mill 19. At the upper portion of the furnace is another set of burners 20 which may receive fuel from a separate mill, or from the mill 19 through a conduit 21 controlled by a valve 22 so that part of the fuel from the mill may be diverted from burners 18 to the burners 20.

As indicated in Fig. 2 the burners 18 are preferably arranged to provide a vortically ascending column of burning gases in the furnace by being mounted in opposite walls in offset relation so that streams of fuel and air projected thereby are substantially tangential to an imaginary circle in the furnace. As shown, the burners are mounted at the corners of the furnace with approximately opposite burners in offset relation.

In the operation of the boiler all the fuel that is needed to generate and superheat to the desired temperature the amount of steam required at high loads is supplied to the burners 18. Inasmuch as burners 18 are arranged in offset relation so as to project the fuel in directions tangential to a circle within the furnace, a swirling column of ascending gases is produced. These gases sweep the generating tubes 17 on the furnace walls and give up considerable of their heat by convection to these walls as well as by radiation. Thus, the major part of the amount of steam required at high loads is generated in the water wall 17. As the gases pass from the furnace and over the generating tubes 11, 12 and the superheater the remainder of the total amount of steam required at high loads is generated and the latter is superheated to the predetermined temperature.

As the demand for steam from the boiler falls, the rate of operation of the main burners 18 at the lower portion of the furnace is decreased. Consequently the amount of heat absorbed by tubes 17 by radiation and the amount of heat imparted by convection to these wall tubes is also diminished by the reduction of the flame envelope so that less steam is generated in the tubes 17.

The products of combustion coming from burners 18 then arrive at the boiler tubes 11, 12 and the superheater at substantially lower temperatures so that a drop in superheat results. However, according to the invention, the firing rate of the burners 18 is reduced and burners 20 are placed in operation and proportionately increased to maintain the quantity of gases produced by both sets of burners at a temperature sufficiently high to generate and superheat the amount of steam required at the lower load. The burners 20 are mounted near the top of the furnace a sufficient distance from the bank 11 to assure complete combustion of the fuel in its path from burner to bank but sufficiently close that the products of combustion therefrom do not impart a substantial amount of heat to the wall tubes 17. The upper burners 20 are so located and directed that they jet their products of combustion into the gases rising from the lower burners 18 and mix therewith. The temperature of the mixture is higher than that of the rising gases from the burners 18 and lower than that of the products of combustion from the burners 20.

The change in the amount of fuel consumed may be effected by reducing the rate of operation of the mill 19 and diverting part of the lesser amount of fuel to the burners 20 by regulating the valve 22 in the conduit 21 leading from the main conduit for burners 18 to the burners 20. However, it is obvious that the burners 20 might be supplied by a separate mill and the respective rates of operation of the two mills controlled in suitable manner to vary the rate of fuel supply as set forth above.

The burners 18 preferably have ample capacity to alone provide an adequate quantity of gases at a temperature sufficiently high to generate and superheat the steam to the desired temperature at maximum loads. However, in some instances it may be desirable to operate the burners 18 at less than their capacity and supply the remaining quantity of gases by means of the burners 20.

Thus, as described above, the amount of heat absorbed from the gases by the wall tubes 17 is changed by varying the location within the furnace of a substantial portion of the heat liberated from the burning fuel with respect to the furnace outlet by apportioning the fuel between burners 18 and 20 in order to maintain the superheat temperature substantially constant.

Where the above method of superheat temperature control is applied to a boiler subject to a very high maximum steam demand, the requirements of auxiliary burners 20 to maintain the superheat temperature at lower loads may become so great that the products of combustion therefrom are too quantitative to satisfactorily mix with those rising from the burners 18. When this occurs the products from the burners 20 may travel in a stratum above the gases from the burners 18 and their temperature may be above the softening temperature of the ash when arriving at the boiler tubes. To avoid this possibility and also keep the auxiliary burners down to a practical number, applicant may, in some cases, employ a superheater of a size which, when contacted by all the gases from burners 18, would over-superheat at high boiler loads and provide a by-pass controlled by a damper 23 to divert some of the gas around the superheater in order to maintain a desired constant superheat temperature at these high loads. The upper set of burners 20 would then be employed as described above only below that rate of operation where the superheat temperature falls below that desired.

By way of example, 2200 degrees F. may be the softening temperature of the ash below which the temperature of the flue gases should be kept upon entering the boiler tube bank. At peak loads the temperature of the gases leaving the furnace produced by burners 18 only may be 2100 degrees F. and the excess superheat is lowered by by-passing some of the gases. At normal load and proper superheat this temperature may be 2000 degrees F. At 60% of normal load this temperature may be 1700 degrees F. and, inasmuch as the temperature of the gases at the outlet from the furnace is insufficient to give the desired superheat temperature the upper set of burners 20 are placed in operation and the firing of the burners 18 reduced as described above. The fresh hot gases from the burners 20 would then raise the temperature of the mixture of gases from both sets of burners to about 1900 degrees F. to maintain the superheat temperature at the point desired.

With this manner of operation at very high

loads the maintenance of a substantially constant superheated steam temperature over a range from around 60% of normal load to low loads is still attained by apportioning the fuel between the burners 18 and 20 to maintain a proper gas temperature at the furnace outlet as has been previously described.

It will be seen that the method disclosed herein permits a substantially constant superheated steam temperature to be maintained over a wide range of boiler loads since the fuel feeding means permit proper quantities of gases to be produced at various loads and the total heat of the gases at the outlet of the furnace may be maintained at the temperatures required because the gases produced by the upper set of burners 20, not being cooled substantially before passing over the main generating and superheating elements, supply any deficiency of heat at low loads.

Although only one form of boiler for carrying out the present invention has been illustrated herein it will be understood that the method may be carried out with various types of boilers having firing means arranged so that part of the gases produced are partially cooled in generating a portion of the required steam, whereas the remainder of the gases produced supply sufficient heat to attain the required gas temperature as a result of passing directly to the main generating and superheating elements without being substantially cooled.

What I claim is:

1. The method of maintaining substantially constant superheated steam temperature in a boiler provided with a convection type superheater which comprises; burning at least the greater portion of the amount of fuel required to produce a quantity of gases at a temperature adequate to generate and superheat to a predetermined temperature the amount of steam required at a determined boiler load; imparting heat from the burning fuel to generating elements for generating part of the amount of steam required; separately burning any additional fuel required and mingling the hot gases therefrom with the gases that have been partially cooled by the extraction of heat therefrom; passing the mingled gases over other generating and the superheating elements to generate the remainder of the total amount of steam required and to superheat the latter to said predetermined temperature; and, as the steam demand falls, decreasing the amount of fuel burned to provide gases from which heat is extracted before passing over said other generating and said superheating elements while substantially proportionately increasing the amount of fuel burned to produce gases passed directly over said other generating and superheating elements for maintaining the gases passing over the latter heated to a temperature adequate to maintain said predetermined superheated steam temperature at low boiler loads.

2. The method of maintaining substantially constant superheated steam temperature over a wide range of loads in a boiler provided with a convection type superheater which comprises; burning at least the greater portion of the amount of fuel required to produce a quantity of gases at a temperature adequate to generate and superheat to a predetermined temperature the amount of steam required at maximum boiler loads; imparting heat by radiation from the burning fuel to generating elements for generating part of said amount of steam; separately burning any additional fuel required and mingling the gases therefrom with the gases that have been partially cooled by the extraction of radiant heat therefrom; passing the mingled gases over other generating and the superheating elements to generate the remainder of the total amount of steam required and to superheat the latter to said predetermined temperature; and, as the steam demand falls, decreasing the amount of fuel burned to provide gases imparting radiant heat to first mentioned generating elements while increasing the amount of fuel burned to produce gases passed directly over said other generating and superheating elements for maintaining the gases passing over the latter heated to a temperature adequate to maintain said predetermined superheated steam temperature at low boiler loads.

3. The method of maintaining substantially constant superheated steam temperature over a wide range of loads in a boiler provided with a convection type superheater which comprises; burning the total amount of fuel required to produce a quantity of gases at a temperature adequate to generate and superheat to a predetermined temperature the amount of steam required at maximum boiler loads; imparting heat from burning fuel to generating elements for generating part of the amount of steam required; passing the partially cooled gases over other generating and the superheating elements to generate the remainder of the total amount of steam required and to superheat the latter to said predetermined temperature; separately burning fuel at low loads and passing the gases therefrom directly over said other generating and the superheating elements; and, as the steam demand falls, decreasing the amount of fuel burned to provide gases heating said first mentioned generating elements while increasing the amount of fuel burned to produce gases passed directly over said other generating and superheating elements for maintaining the gases passing over the latter heated to a temperature adequate to maintain said predetermined superheated steam temperature at low boiler loads.

4. The method of maintaining substantially constant superheated steam temperature over a wide range of steam demand in a boiler provided with a convection type superheater which comprises; burning a portion of the total amount of fuel required to produce a quantity of gases at a temperature adequate to generate and superheat to a predetermined temperature the amount of steam required at low loads, passing said gases directly over the main generating and superheating elements of the boiler; separately burning the remainder of said amount of fuel and imparting heat therefrom to other steam generating elements before passing said gases over the main generating and superheating elements; and, upon increases in load, decreasing the portion of fuel burned to produce gases passed directly over said main generating and superheating elements while increasing the portion of fuel burned to produce gases from which heat is extracted to generate steam prior to being passed over said main generating and superheating elements.

5. The method of maintaining substantially constant superheated steam temperature in a boiler having separate sets of fuel burners near the top and bottom respectively of its furnace chamber, generating elements which absorb heat only from the gases produced by the lower set of burners, and other generating and superheating elements in the path of gases from both sets of burners, which comprises; supplying the lower set

of burners with at least the greater portion of the total fuel required to produce gases at a temperature adequate to generate and superheat to a predetermined temperature the total amount of steam required at a determined boiler load; imparting heat from said gases to said generating elements which are heated only by the lower set of burners; passing the partially cooled gases from the furnace over said other generating and the superheating elements; supplying the upper set of burners with any additional fuel required to generate said amount of steam and attain said predetermined superheat temperature and passing the gases therefrom directly over said other generating and superheating elements; and as the steam demand falls, decreasing the amount of fuel supplied to the lower set of burners while increasing the amount of fuel supplied to the upper burners so that the temperature of gases is sufficiently high to maintain said predetermined superheated steam temperature at low loads.

6. The method of maintaining substantially constant superheated steam temperature in a boiler having separate sets of fuel burners near the top and bottom respectively of its furnace chamber, generating elements on the furnace walls which absorb heat only from the gases produced by the lower set of burners, and other generating and superheating elements in the path of gases from both sets of burners, which comprises; supplying the lower set of burners with at least the greater portion of the total fuel required to produce gases at a temperature adequate to generate and superheat to a predetermined temperature the total amount of steam required at a determined boiler load; imparting heat from said gases to said generating elements on the furnace walls; passing the partially cooled gases from the furnace over said other generating and the superheating elements; supplying the upper set of burners with any remaining fuel required to generate said amount of steam and attain said predetermined superheat temperature and passing the gases therefrom directly over said other generating and superheating elements; and, as the steam demand falls, decreasing the amount of fuel supplied to the lower set of burners while increasing the amount supplied to the upper burners so that the temperature of the gases is sufficiently high to maintain said predetermined superheated steam temperatures at low loads.

7. The method of maintaining a substantially constant superheated steam temperature in a boiler having a set of burners at or near the top of its furnace for generating a volume of gas which is passed directly over the main generating and the superheating elements of the boiler and another set of burners adjacent the bottom of the furnace arranged to impart radiant heat to metallic bodies to generate part of the steam before the gases therefrom mingle with those from the upper set of burners to pass over said main generating and the superheating elements, which comprises; supplying the lower set of burners with the total fuel required to produce gases at a temperature to generate and superheat to a predetermined temperature the total amount of steam required at a determined boiler load; imparting a portion of the heat of said gases by radiation to said metallic bodies for generating part of the steam required at said load; passing the partially cooled gases over the main generating and superheating elements to generate the remainder of the total amount of steam required at said load and to superheat the latter to a predetermined temperature; supplying fuel to the upper set of burners at low loads and passing the gases therefrom directly over the main generating and the superheating elements; and, as the steam demand falls, decreasing the amount of fuel supplied to the lower burners while increasing the amount of fuel supplied to the upper burners to maintain said gases heated to a temperature sufficiently high to attain said predetermined superheated steam temperature at low loads.

8. The method of maintaining substantially constant superheated steam temperature in a boiler having a furnace substantially uniformly surrounded by heat absorbing elements and a convection type superheater and other generating elements located beyond the furnace outlet and heated by gases therefrom which comprises; burning fuel in suspension in the lower portion of the furnace and imparting heat from the gases produced thereby to said heat absorbing elements; passing the gases from the furnace over said superheater and other generating elements; and, varying the amount of heat absorbed by said heat absorbing elements by introducing fuel into the upper portion of the furnace and burning it therein while reducing the amount of fuel burned in the lower portion of the furnace to vary the location within the furnace of a substantial portion of the heat liberated from the burning fuel with respect to the furnace outlet.

9. The method of maintaining substantially constant superheated steam temperature in a boiler having a furnace substantially uniformly surrounded by heat absorbing elements and a convection type superheater and generating elements located beyond the furnace outlet in the path of gases therefrom which comprises; introducing the total amount of fuel required to produce a quantity of gases adequate to generate and superheat to a predetermined temperature the amount of steam required at a determined boiler load through opposite walls in the lower portion of the furnace in direction tangential to an imaginary circle within the furnace for producing a vortical column of burning fuel and gases sweeping the heat absorbing elements on the furnace walls and yielding heat thereto by convection as well as by radiation to generate part of the amount of steam required; passing the partially cooled gases over the other generating and superheating elements to generate the remainder of the total amount of steam required and superheat the latter to said predetermined temperature; and, as the steam demand falls, separately burning fuel in the upper portion of the furnace and passing the gases therefrom directly over said other generating and the superheating elements and decreasing the amount of fuel introduced into the lower portion of the furnace for reducing the amount of heat imparted to said heat absorbing elements by convection while maintaining the gases passing over said other generating and superheating elements heated to a temperature adequate to maintain said predetermined superheated steam temperature.

10. The method of maintaining a substantially constant superheated steam temperature in a boiler having a furnace chamber provided with heat absorbing elements. and other generating elements and a convection type superheater located beyond the furnace outlet in the path of gases therefrom, which comprises; burning in said furnace an amount of fuel adequate to produce gases sufficient in quantity and temperature

to generate all of the steam required at maximum load but which would superheat the steam above a desired, predetermined temperature; imparting heat from said gases to said heat absorbing elements; passing all of the partially cooled gases over said other generating elements to generate the remainder of the steam while by-passing a sufficient part of said gases around the superheater to maintain the superheated steam at said predetermined temperature; reducing the amount of fuel burned to produce gases imparting heat to said heat absorbing elements as the steam demand falls; and, as the steam demand falls to a point below which the volume and temperature of the gases imparting heat to said heat absorbing elements are inadequate to maintain said predetermined steam temperature, separately burning fuel to produce a volume of gases which do not impart a substantial amount of heat to said heat absorbing elements; mixing said separately produced gases with the gases which have been partially cooled by imparting heat to said heat absorbing elements for raising the temperature of the gases to a point sufficiently high to superheat the steam to said predetermined temperature; and passing the entire volume of co-mingled gases over the superheater as well as said other generating elements.

11. The method of maintaining a substantially constant superheated steam temperature in a boiler as recited in claim 10 wherein the amount of fuel producing gases imparting heat to said heat absorbing elements is progressively decreased as the steam demand falls and the amount of fuel burned to produce gases not imparting heat to said heat absorbing elements is progressively increased as steam demand falls for maintaining the temperature of the comingled gases sufficiently high to maintain said predetermined superheated steam temperature at low loads.

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