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J. V. PYLE

2,313,841

STEAM GENERATOR

Filed June 27, 1940

3 Sheets-Sheet 1

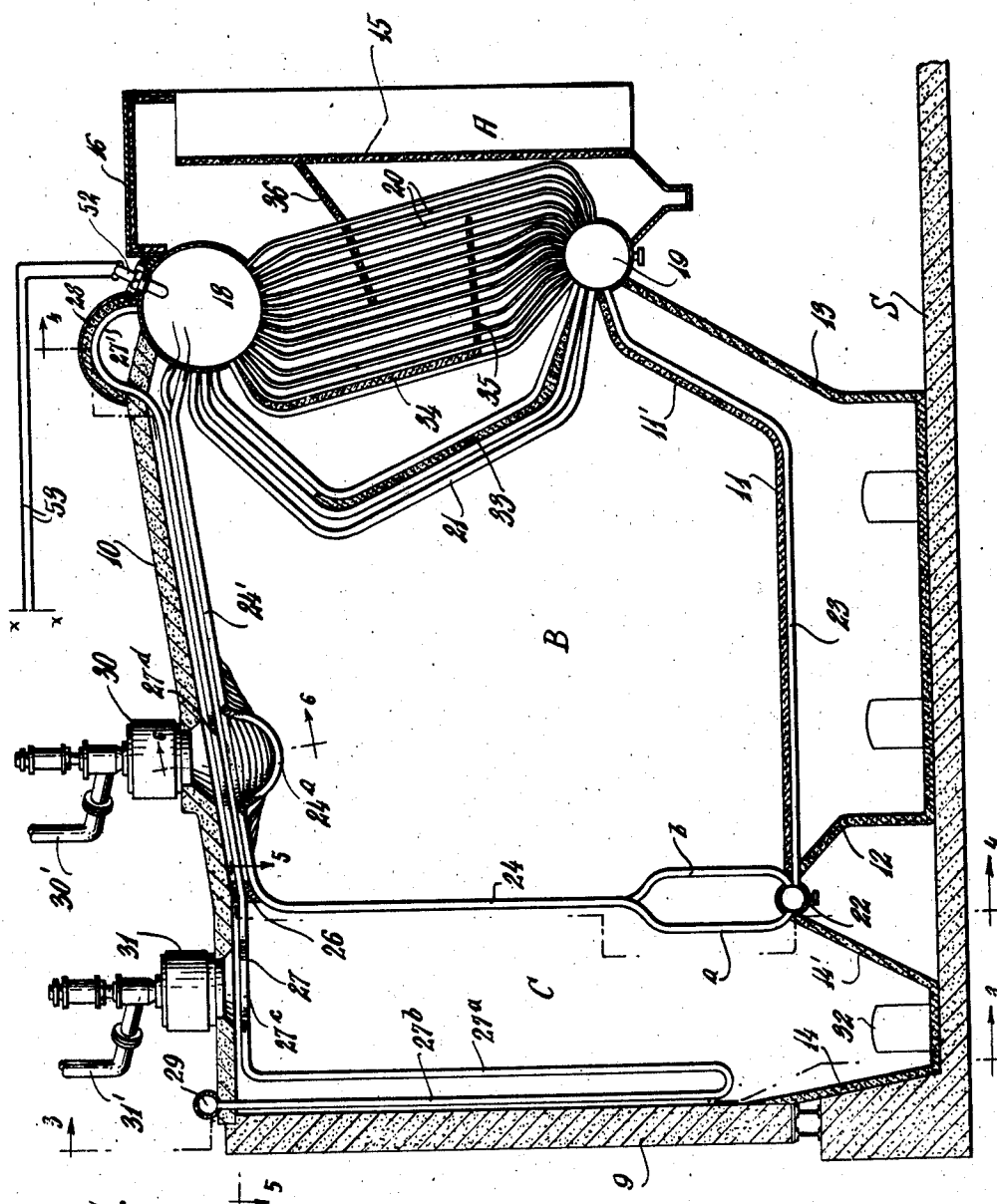


Fig. 1.

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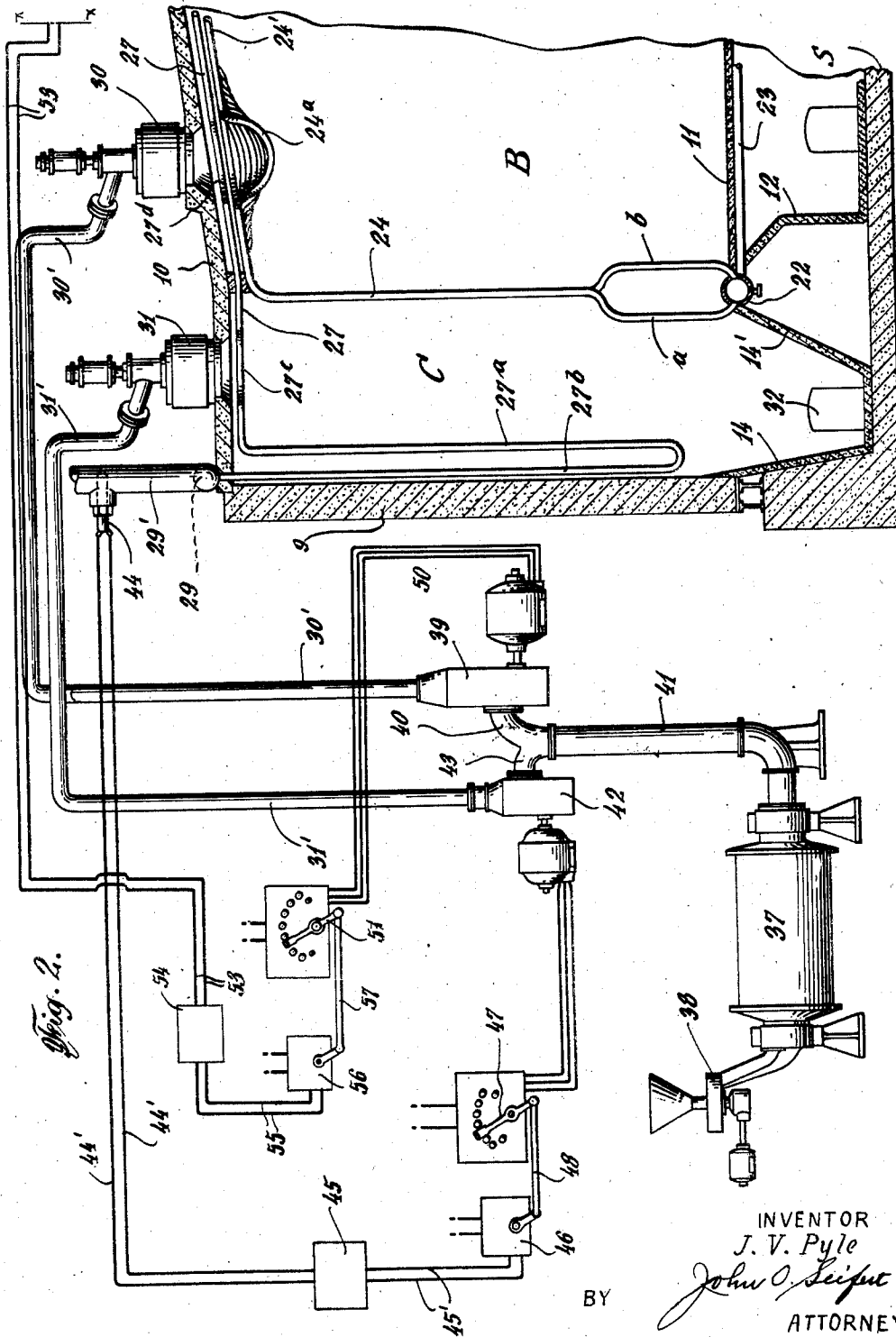
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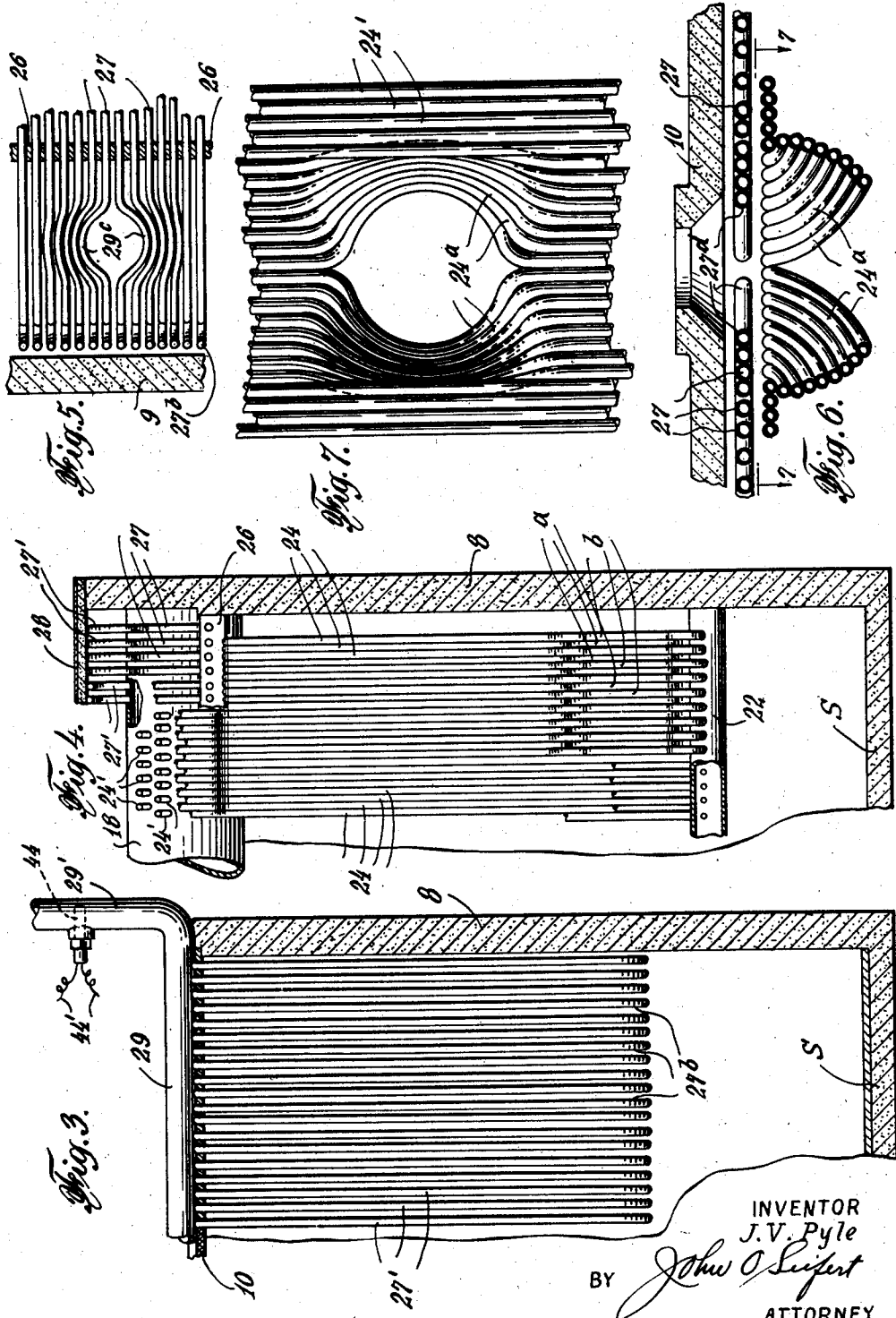
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STEAM GENERATOR

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6 Claims. (Cl. 122—479)

This invention relates to steam generating units including a steam superheater and the providing of steam superheated within a predetermined temperature. In the operation of steam turbines, engines, and similar devices, and in the use of steam in process work, it is essential that the temperature of the steam be maintained below or not higher than a predetermined temperature, otherwise it will result in material injury and damage to turbines or engines, or the work being processed. In steam generating units the superheater element or elements are connected to the steam space of a steam drum of a boiler and are disposed relative to the furnace chamber for the boiler to be subjected to the hot gases of combustion flowing relative to the boiler and the superheated steam delivered to the place of use. Should the superheater have a capacity only sufficient to produce superheated steam of a desired temperature when the steam generating unit is operated under high load, it is of insufficient capacity to produce superheated steam of the desired temperature when the steam generating unit is operated under low load. The superheater is, therefore, made of such size and so arranged relative to the flow of the hot gases of combustion from the boiler furnace that superheated steam of the desired temperature will be produced when the steam generating unit is operated under low load, with the result that when the steam generating unit is operated under high load the steam is superheated to a higher temperature than the desired or predetermined temperature.

The present application is a continuation in part of my application Serial No. 279,004, filed June 14, 1939, and it is an object of the present invention to provide an improved construction and arrangement of steam generating unit including a superheater to produce superheated steam of a constant predetermined temperature in the operation of the steam generating unit over a wide range of output ratings of the steam generating unit.

A further object of the invention is the provision in a steam generating unit of a furnace for the boiler having a main combustion chamber and an auxiliary or superheater combustion chamber having independent fuel burning means and means controlled by the temperature of the superheated steam operative to regulate the fuel supply to fuel burning means for the superheater combustion chamber and produce and deliver superheated steam having substantially a predetermined temperature.

It is another object of the invention to provide in a steam generating unit a furnace having groups of steam generating tubes therein defining a main combustion chamber and an auxiliary combustion chamber having a steam superheater therein connected in communication with and for passing steam therethrough from the steam generating tubes, independent fuel burning means for firing each of said chambers and means for supplying fuel to the fuel burning means, the provision of means controlled by the temperature and pressure of the generated steam for regulating the means for supplying fuel to the fuel burning means for and firing the main combustion chamber and the generating of saturated steam of a predetermined pressure and temperature, and means controlled by the temperature of the superheated steam for regulating the means for supplying fuel to the fuel burning means for and firing of the auxiliary combustion chamber to produce superheated steam of and retain it at a predetermined temperature.

Other objects and advantages of the invention will hereinafter appear.

In the drawings accompanying and forming a part of this application,

Figure 1 is a longitudinal sectional view of a steam generating unit illustrating an embodiment of the invention.

Figure 2 is a sectional view of a portion of the steam generating unit shown in Figure 1 and showing in elevation means in connection therewith for supplying fuel to fuel burners and means to regulate the operation of the fuel supply means for the burners controlled by the temperature of the superheated steam.

Figure 3 is a fragmentary cross sectional view taken on the line 3—3 of Figure 2 to show the arrangement of the steam superheater elements.

Figure 4 is a fragmentary sectional view taken on the line 4—4 of Figure 1 and showing the arrangement of the row of sidewise arranged tubes separating the furnace into main and auxiliary combustion chambers.

Figure 5 is a sectional view taken on the line 5—5 of Figure 1 showing the arrangement of the superheater elements to adapt the same for firing the superheater combustion chamber.

Figure 6 is a sectional view taken on the line 6—6 of Figure 1, showing the arrangement of tubes of the steam superheater and of the tubes separating the furnace into main and auxiliary combustion chambers for firing the main combustion chamber; and

Figure 7 is a detailed plan view taken on the line 7-7 of Figure 6.

In carrying out the embodiment of the invention illustrated in the drawings the boiler and boiler furnace are arranged on a setting S, the furnace being of substantially rectangular form in horizontal and vertical cross section and formed by opposite side walls 8, a front wall 9, a top wall or roof 10 and a bottom wall or floor 11 arranged with a horizontal portion and an upwardly and rearwardly diverging portion 11'. The floor 11 commences at a point within the front furnace wall and is spaced above a pit formed by a horizontal wall portion, vertical side walls and end walls having a vertical portion merging in an upwardly diverging portion, as at 12 and 13. The bottom of the furnace forwardly of the floor 11 is arranged of downwardly converging wall portions 14, 14' forming in effect a pit. The rear wall of the furnace is defined by a vertically disposed air preheater A, the inner vertical wall of which air preheater open to the furnace is provided with a facing of a refractory or heat resisting material 15, and a horizontal wall portion 16 connecting the inlet to the top of the air preheater in communication with the furnace.

A two drum boiler is disposed in the rear of the furnace, comprising upper and lower horizontal drums 18, 19, the lower drum having the usual drain outlet and the upper drum the usual water inlet and safety outlet. The upper drum extends transversely of the furnace at the rear of the upper furnace wall, and the lower drum is disposed relative to the rear of the upwardly and rearwardly diverging portion of the furnace floor 11 and the wall 13 of the pit. The drums are connected in water circulation by a bank of vertical tubes 20 connected to the upper drum below the axis thereof and to the lower drum above the axis thereof; the drums are connected by a second bank of steam generating tubes 21 connected at one end to the lower drum above the axis thereof with a portion of the tubes diverging forwardly and upwardly from the lower drum into the furnace and a portion diverging rearwardly connected to the upper drum in the plane of and above and below the horizontal axis of the drum and thereby effecting separation of water from steam delivered by said tubes into said upper drum. The banks of tubes 20, 21 are arranged with one side thereof open to the furnace.

The furnace is separated into a water cooled wall main combustion chamber B and an auxiliary combustion chamber C. For this purpose a header or manifold 22 is extended transversely of and intermediate the ends of the furnace, and shown as disposed at the forward end of the furnace floor 11 and is connected in water circulation with the lower drum by a horizontal row of tubes 23 spaced laterally of the furnace, the tubes being arranged below and following the contour of the furnace floor 11, the furnace floor preferably comprising strips of refractory material extending longitudinally of and supported in laterally spaced relation upon the tubes and arranging the same as an ash screen bottom. A row of steam generating tubes arranged in contiguous sidewise relation extends transversely of the furnace, said tubes having a portion 24 extending vertically of the furnace to adjacent the top wall of the furnace and then curved laterally with a portion 24' extending along said top wall and connected to the upper drum above the

axis thereof, the ends of the successive tubes being offset alternately in opposite directions; that is, the ends of adjacent tubes being offset laterally in opposite directions, as shown at 25. The vertically extending portions of the tubes separate the furnace into the chambers B and C and the waste hot gases and products of combustion exit from the chamber C to the chamber B and from the latter through the air preheater to a stack. To provide a passage for said gases a portion of successive tubes is offset alternately in opposite directions and thus providing passes between the offset portions of adjacent tubes. As shown, the ends of the vertical portions 24 of the tubes are offset and connected at said offset ends to the header 22, certain of the tubes being offset in one direction, as at a, and alternating tubes being offset in the opposite direction, as at b. To shut off the chambers B and C through the space between the top wall or roof of the furnace and the portions 24' of the tubes extending along the roof a partition of refractory material is arranged between the bends of the tubes and the top of the furnace, as at 26.

A superheater for the steam connected to the steam space in the upper drum 18 is disposed in the auxiliary or superheater chamber C. As shown, this steam superheater comprises a row of tubes spaced laterally of the furnace having a portion 27 extending along the top of the chamber B, through the partition 26 and along the top of the chamber C. The one end of the tubes is curved upwardly and then downwardly and connected to the upper drum 18 above the axis thereof, as shown at 27', the curved portions of the tubes being enclosed by a heat resisting material 28, which is extended over the top of the drum 18. The opposite end portions of the tubes are arranged to extend transversely of the top of chamber C to adjacent the front furnace wall 9 and extended vertically downward to a point above the bottom of the furnace, as at 27a, and then reversely curved in a direction toward the front furnace wall and extended vertically upward in spaced relation to said furnace wall, as at 27b, and connected to a header or manifold 29 from which the superheated steam is led to a place of use, such as a turbine or engine or for processing work.

The chambers B and C are individually fired by fuel burning means, shown as burners 30, 31 for fluent fluid, such as pulverized coal in suspension in an air stream, the burners being mounted relative to openings in the top of the furnace and connected by conduits 30' and 31' to means for supplying or delivering fuel to the burners from a source of supply.

By the construction and arrangement described, easy access is afforded, as through an ash removing opening 32, to the superheater elements, as well as to the tubes forming the separating wall of the furnace for installation, inspection and maintenance. Furthermore, by arranging the superheater in a separate combustion chamber or space the possibility of overheating the superheater tubes when the boiler is started up is eliminated since the superheater is protected from the flow of the hot gases of combustion to the boiler. Also, by this arrangement the superheater affords no resistance to the flow of the gases of combustion and therefore there will be substantially less draft loss through the boiler than in the conventional method of locating the heating surfaces of the superheater, thereby effecting a very substantial saving in

power required for operating a draft inducing fan and in the use of a stack requiring a smaller stack. By arranging the superheater in a combustion chamber separate from the combustion chamber for the boiler the major portion of the superheater element will be subjected to radiant heat of combustion and thus the heating surface or surfaces of the steam superheater may be less than if heated by convection, and by the arrangement of connecting the superheater combustion chamber with the boiler combustion chamber the heat of the gases exiting from the superheater chamber is available for generating steam in the boiler combustion chamber and the gas passes of the boiler.

A series of baffles are provided to cause the hot gases of combustion from the boiler combustion chamber B to pass upwardly and longitudinally of the tube bank 21, then downwardly between said tube bank and the tubes of bank 20, and then upwardly relative to said latter tube bank and provide a circuitous passage and three passes for the flow of the gases at substantially a right angle to the tubes of the tube bank 20 through the inlet to the air preheater A. One of the baffles 33 extends from the lower drum 19 between the rear rows of the tubes of the tube bank 21 to adjacent the point at which said tubes diverge rearwardly. A second baffle 34 extends downwardly from the upper drum 18 in the space between the first and second rows of the tubes of the tube bank 20, said baffle following the contour of said tubes and is of a length substantially equal to two-thirds of the length of the tubes, and then is extended rearwardly substantially in a horizontal plane, as at 35, transversely of the tube bank 20 to within the third rear row of the tubes of said tube bank. A further baffle 36 declines from the air preheater and intersects the tubes of the tube bank 20 substantially midway the baffle 35 and the upper drum and extends transversely of substantially one-half of the tubes of said tube bank. This arrangement and proportionment of the baffles increases the mass velocity of the flow of the hot gases as they pass through the successive passes assuring a maximum transfer and absorption of the heat of the gases of combustion by the boiler elements.

The boiler combustion chamber, as in boilers of this character, is provided with water cooling tubes at the side walls for which purpose headers or manifolds connected to the lower drum are disposed below the furnace floor and extending transversely of the side walls, and said headers connected in circulation with the upper drum by tubes connected to said headers disposed relative to the side walls and either directly connected about the opposite ends of the upper drum or to transverse headers disposed relative to the top of the side walls of the furnace and connected to the upper drum, as is usual in this type of boiler furnace.

To prevent the flame from the burner 31 impinging against the portions of the superheater tubes disposed relative to the top of the furnace the portion of the tubes 27 extending relative to said burner are offset laterally, as shown at 27c in Figure 5. To prevent the flame from burner 30 from impinging against the portion of the superheater tubes 27 disposed relative to the top of the furnace they are also offset laterally similar to the offset portion 27c relative to the burner 31, as shown at 27d in Figure 6, and to prevent the flame from said burner 30 impinging against the portion 24' of the furnace separating tubes

24 the portion of said tubes relative to said burner are offset inwardly and laterally, as shown at 24a in Figure 6, forming an opening substantially as shown in Figure 7.

As stated, it is not only desirable but essential that in the operation of steam turbines and engines and for use in processing work that the superheated steam be maintained within a predetermined temperature. To effect this result means are provided to regulate and control the supplying of fuel to the burner 31 for and firing the superheater combustion chamber C. In the embodiment of the invention illustrated means are shown for pulverizing coal and delivering the same in suspension in air streams to the burners 30, 31, and comprises a tube mill 37 provided with means for feeding coal thereto from a hopper or bin, as shown in a conventional manner at 38. The pulverized coal is drawn from the mill and delivered to the burner 30 in suspension in an air stream by a motor driven fan 39 through the conduit 30' connected to the outlet of said fan, the intake of the fan being connected by a branch conduit 40 to a conduit 41 connected to the outlet of the mill. Pulverized coal in suspension in an air stream is delivered from the mill to the burner 31 through the conduit 31' connected to the outlet of a motor driven fan 42 the intake of which fan is connected through a branch conduit 43 to the conduit 41 connected in communication with the outlet of the mill.

To heat the superheated steam to and maintain it at a substantially constant temperature means are provided to control the operation of the motor for the fan 42 and thereby regulate the supply of fuel to the burner 31 and firing of the superheater chamber C controlled by the temperature of the superheated steam. For this purpose a temperature responsive member, such as a thermo coupling or thermo circuit making switch, is interposed in the superheater outlet, and shown as mounted in and intersecting the outlet member 29' for the superheater steam from the manifold or header 29, as shown at 44 in Figure 2. The thermo switch member 44 is electrically connected by conductors 44' to a control device, shown in a conventional manner at 45, and when the steam rises to a predetermined temperature the thermo switch member 44 is actuated to close the circuit of the control device 45 which is connected by conductors 45' to and renders an electrically operated device or motor 46 active to actuate a movable circuit making member 47 of a rheostat device interposed in the electric circuit of the motor for the fan 42 to slow down or stop said motor and thereby reducing or stopping the supply of fuel to the burner 31, the electrically operated device 46 being operatively connected to the circuit maker 47 of the rheostat device by a rod, as shown at 48. The reduction in the supply of fuel to the burner 31 is maintained, or such fuel supply shut off from said burner, until the temperature of the steam is lowered to or below said predetermined temperature when the thermo coupling or switch member 44 is actuated to open the circuit of the control device and thereby render the motor 46 inactive and the movable circuit maker 47 of the rheostat device to assume position to operate the motor for fan 42 at full load. By regulating and controlling the firing of the superheater combustion chamber C by the temperature of the superheated steam the superheated steam will be maintained at or below a predetermined temperature and may be utilized in the

operation of turbines and engines as well as used in process work without possible injury or damage by the excessive heat of the superheated steam.

To control the generating and passing of saturated steam through the superheater means are provided to control the delivery of fuel to the burner 30 and the firing of the steam generating combustion chamber controlled by the pressure or temperature of the generated steam. For this purpose there is interposed in the conductors 50 of the operating electric circuit of the actuating motor for the fan 39 a rheostat device including a movable circuit making member 51 operative to slow down or stop said motor and thereby reduce or stop the supply of fuel to the burner 30. As shown, the actuation of the movable circuit making member 51 of the rheostat device is controlled by a temperature responsive member, such as a thermo coupling or thermo circuit making switch 52 disposed to be subjected to the action of the generated steam and shown as mounted in the drum 18 exposed to the steam space therein. The thermo switch member is electrically connected by conductors 53 to a control device, shown in a conventional manner at 54, which is connected by conductors 55 to an electrically operated device or motor 56 operatively connected to the circuit making member 51 of the rheostat device by a rod 57. When the generated steam rises to a predetermined temperature the thermo switch member is actuated to close a circuit of the control device 54 which renders the motor 56 active to actuate the movable circuit making member of the rheostat device to slow down or stop the actuating motor for the fan 39 and thereby reducing or stopping the supply of fuel to the burner 30. The reduction in the supply of fuel to the burner 30 is maintained, or such fuel supply shut off from said burner, until the temperature and thereby the pressure of the steam is lowered to or below said predetermined temperature when the thermo switch opens the circuit of the controlling device 55 thereby rendering the motor 56 inactive and permitting the movable member of the rheostat device to assume a position to operate the motor for the fan 39 at full load.

It will be obvious that various modifications may be made in the construction and arrangement of the parts without departing from the scope of the invention, and that portions of the invention may be used without others and come within the scope of the invention.

Having described my invention, I claim:

1. In a steam generator, including a steam generating combustion chamber and an auxiliary combustion chamber having a steam superheater therein, a pulverized fuel burner opening to and individually firing each of said chambers, means having an independent connection with each burner to connect the burners to a source of fuel including an electric motor driven fan in the connection of each burner operative to deliver fuel to each of said burners, and means including a temperature responsive element disposed at the outlet of the superheater operative by the temperature of the superheated steam to regulate the operation of the motor for the fan delivering fuel to the burner firing the auxiliary combustion chamber and produce superheated steam having a predetermined temperature.

2. In a steam generator including a combustion chamber having groups of steam generating

tubes therein and a combustion chamber having a steam superheater therein connected in communication with and for passing steam there-through from the steam generating tubes, a pulverized fuel burner opening to and for firing each of said combustion chambers, means for independently connecting each burner to fuel supply means and each connection including an electric motor driven fan for delivering fuel to each burner, electrically operated means including a temperature responsive element operative by the temperature of the superheated steam for regulating the operation of the motor for the fan delivering fuel to the burner firing the superheater combustion chamber to heat the superheated steam to and maintain it at a predetermined temperature, and electrically operated means including a temperature responsive member operative by the temperature of the generated steam for regulating the operation of the motor for the fan delivering fuel to the burner firing the steam generating combustion chamber and the generating and passing of saturated steam at a predetermined temperature and pressure through the steam superheater.

3. In a steam generating unit including a combustion chamber having steam generating elements therein, and an auxiliary combustion chamber having a steam superheater therein connected in communication with and for passing steam therethrough from the steam generating elements, a pulverized fuel burner for independently firing each combustion chamber, a fuel pulverizer, electric motor driven fans connected to the pulverizer and one of said fans connected to and delivering fuel from the pulverizer to one of said burners and the other fan delivering fuel to the other burner, electrically operated regulator means for controlling the operation of the motor for the fan delivering fuel to the burner firing the auxiliary combustion chamber, and a temperature responsive element operative by the temperature of the superheated steam to control the operation of said motor regulator means and the actuation of the motor for said fan to deliver fuel to said burner and fire the auxiliary furnace to heat the superheated steam to and maintain it at a predetermined temperature.

4. In a steam generating unit including a combustion chamber having steam generating elements therein and an auxiliary combustion chamber having a steam superheater therein, a pulverized fuel burner opening to and firing each of said combustion chambers, means connected to a fuel supply including independent electric motor driven fans for delivering fuel to each burner, regulating means including a rheostat device in the circuit of and operative to regulate the operation of each fan motor and delivery of fuel to each burner, a temperature responsive element operative by the temperature of the generated steam to control the actuation of the regulating means for the motor for the fan delivering fuel to the burner firing the steam generating combustion chamber and the temperature and pressure of the generated steam, and a temperature responsive element operative by the temperature of the superheated steam to control the actuation of the regulating means for the motor for the fan delivering fuel to the burner firing the superheater combustion chamber and the heating of the superheated steam to a predetermined temperature.

5. In a steam generator including a combus-

tion chamber having groups of steam generating tubes therein and an auxiliary combustion chamber having a steam superheater therein connected in communication with and for passing steam therethrough from the groups of steam generating tubes, a pulverized fuel burner for firing each of said combustion chambers, means for independently connecting the burners to a source of fuel including an electric motor driven fan operative for supplying fuel independently to each burner, means independently operative for regulating the operation of each fan motor and feeding of fuel to the burners, temperature responsive means operative by the temperature of the superheated steam to control the actuation of the regulating means and operation of the motor for the fan supplying fuel to the burner firing the superheater combustion chamber and heating of the superheated steam to and maintaining it at a predetermined temperature, and temperature responsive means operative by the temperature of the generated steam to control the operation of the regulating means for and actuation of the motor for the fan supplying fuel to the burner firing the steam generating combustion chamber and the generating and passing of saturated steam of a predetermined temperature and pressure to the steam superheater.

6. In a steam generating unit including a pair of combustion chambers, one of said combustion chambers having steam generating elements

therein and the other combustion chamber having a steam superheater therein connected in communication with and for passing steam therethrough from the steam generating elements, a pulverized fuel burner for firing each of said combustion chambers, a fuel pulverizer, a pair of electric motor driven fans connected to the pulverizer and a fan connected to and delivering fuel to each of said burners, electrically operated regulator means connected in the circuit of each fan motor operative to regulate the operation of the motors and fans and delivery of fuel to the burners, a thermo switch connected in the circuit of the regulator means for the motor of the fan delivering fuel to the burner firing the superheater combustion chamber to control the operation of said regulating means to regulate the actuation of said motor and fan to deliver fuel to said burner to heat the superheated steam to and maintain it within a predetermined temperature, and a thermo switch connected in the circuit of the regulator means for the motor of the fan delivering fuel to the burner firing the steam generating combustion chamber and operative to control the operation of said regulating means to regulate the actuation of said motor and fan to deliver fuel to said burner and generate steam of a predetermined temperature and pressure and passing of said steam through the superheater.

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