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STEAM GENERATING UNIT

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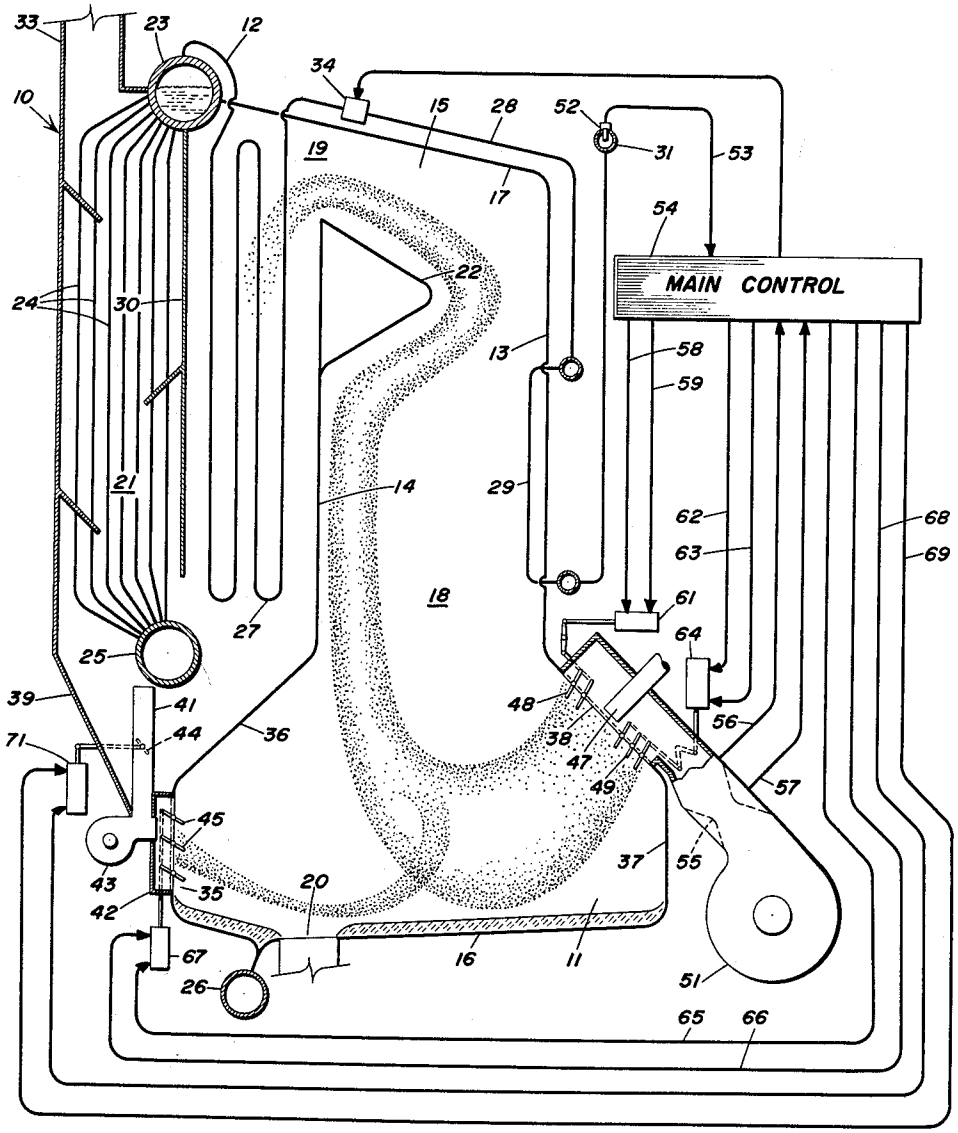


FIG. 1.
HIGH LOAD

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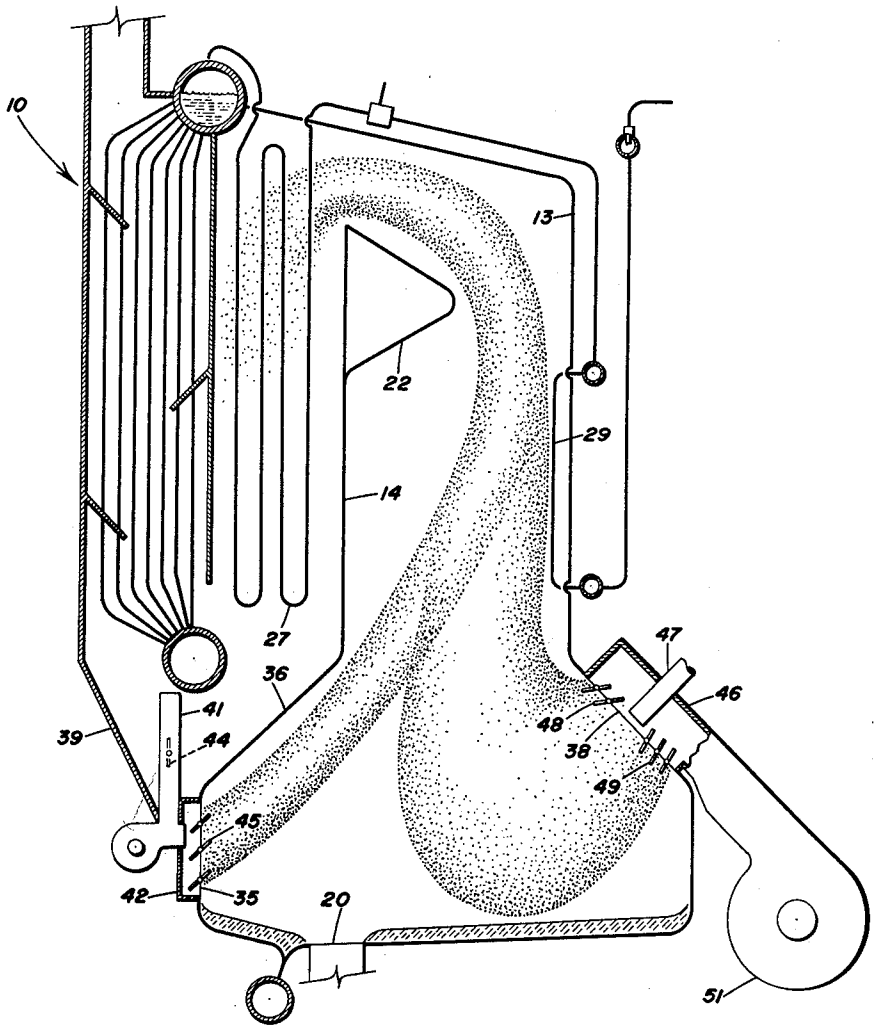


FIG. 2.
LOW LOAD

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STEAM GENERATING UNIT

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This invention relates to a steam generating unit and more particularly to apparatus arranged to produce steam for use in a turbine in the generation of electricity.

In producing steam for use in a turbine, the final steam temperature, as the steam leaves the unit on its way to the turbine, is quite critical. This is because the turbine operates at its greatest efficiency at a single design pressure and temperature. It is difficult, if not impossible, to make a basic boiler which will give the same temperature of steam at widely differing loads or rates of heat release. Various means have been conceived for maintaining the superheated steam at a constant temperature value in large steam generating units, in which the cost of the unit is so large that it is possible to resort to complicated and expensive methods of control. In units of intermediate and small size, however, the cost of the basic furnace and boiler unit does not warrant an expensive steam temperature control. For that reason, the regulation of steam in these smaller units has not been good and the turbine efficiency has been less than the optimum. These and other difficulties experienced with the prior art devices have been obviated in a novel manner by the present invention.

It is, therefore, an outstanding object of the invention to provide a steam generating unit having a novel means for maintaining the temperature of superheated steam at a constant pre-determined value.

Another object of this invention is the provision of a steam generating unit of intermediate size having an inexpensive means for maintaining superheat temperature at a pre-selected value throughout a broad range of loads.

A further object of the present invention is the provision of a waist-line steam generating unit of intermediate load capacity which has relatively inexpensive construction characteristics but which, nevertheless, provides the advantages of complete combustion in a lower portion of the furnace, small overall height of the combustion chamber, and even gas temperature from side to side of the unit passing into the convection passes.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

The character of the invention, however, may be best understood by reference to one of its structural forms as illustrated by the accompanying drawings in which:

FIG. 1 is a vertical sectional view of a steam generating unit embodying the principles of the present invention, the operation being shown at high load, and

FIG. 2 is a somewhat schematic view of the unit as showing the operation at low load.

Referring first to FIG. 1, wherein are best shown the general features of the invention, the steam generating unit, indicated generally by the reference numeral 10, is shown as consisting of a furnace 11 and a boiler 12. The furnace consists of a front wall 13, a rear wall 14, side walls 15, a bottom wall 16, and a roof wall 17 defining a vertically-elongated combustion chamber 18. At its upper end the combustion chamber 18 is connected by a gas off-take 19 to a back pass 21. The rear wall 14 is provided with a nose 22 extending into the combustion chamber immediately under the gas off-take 19.

The boiler 12 is provided with a steam-and-water drum 23 located over the back pass 21 and connected by downcomer tubes 24 to a lower mud drum 25. The mud drum is connected by downcomer tubes (not shown) to a header 26 underlying the bottom wall 16 of the furnace. Tubes extend upwardly from the header 26 along the bottom wall 16 and up the front wall 13, the rear wall 14, and the side walls 15; these wall tubes terminate in the steam-and-water drum 23 in the usual manner. The tubes overlying the bottom wall 16 of the furnace are spread in a given area to provide a slag tap opening 20 and, generally speaking, the bottom wall tubes are protected by refractory material in the usual way. The steam-and-water drum 23 is connected at its upper portion to a convection superheater 27 which lies in the convection pass 21 and is connected by a pipe 28 to a radiant superheater 29 located at the upper portion of the front wall 13. The outlet of the radiant superheater 29 is connected to a superheated steam header 31 from which the steam passes to the turbine (not shown).

Extending downwardly from the bottom of the steam-and-water drum 23 is a baffle 30 which terminates at its lower end somewhat short of the upper part of the mud drum 25. The back pass is divided by the baffle into a front portion in which the convection superheater 27 lies and a rear portion in which lie the downcomers 24, there being small baffles extending across the rearward portion of the back pass to cause a sinuous flow of gas upwardly through it, the upper part terminating in a breaching 33 leading to the stack (not shown). A desuperheater 34 is connected in the pipe 28 between the convection superheater 27 and the radiant superheater 29.

The rear wall 14 is provided with a short vertical portion 35 adjacent the bottom wall 16 which merges at its upper end into a downwardly-directed inclined portion 36. The front wall 13 of the furnace is also provided with a short vertical portion 37 adjacent the bottom wall 16 and an inclined portion 38 extending from its upper end. It can be seen, therefore, that the combustion chamber 18 is divided into two portions. First there is a high-temperature lower portion defined by the bottom wall 16, the vertical portions 35 and 37, and the inclined portions 36 and 38. Then, this bottom portion merges by a restricted outlet into a considerably narrower upper portion which terminates in the gas off-take 19.

The back pass 21 is provided in its lower portion with a fly-ash hopper 39, the forward inclined wall of which is the inclined portion 36 of the rear wall 14. The mud drum 25 is located above the normal level of fly-ash in the hopper 36. Extending upwardly in the hopper 36 is a vertical recirculated gas pipe 41 whose upper end lies under and close to the mud drum 25. This pipe extends downwardly and is connected to recirculated gas inlet 42 located in the vertical portion 35 of the rear wall 14. A fan 43 provides, by use of the well-known ejector action, for the flow of gas down the pipe 41 and through the inlet 42 into the combustion chamber. The pipe 41 is provided with a damper 44 for regulating the amount of gas which is recirculated back to the furnace and the inlet 42 is provided with angularly adjustable vanes 45 which regulate the direction of flow of the recirculated gas into the combustion chamber.

Mounted on the inclined portion 38 of the front wall 13 is a directional flame burner 46 having a fuel gun 47 and having upper vanes 48 and lower vanes 49. A forced draft fan 51 is connected to the burner to provide it with secondary air.

The superheated steam header 31 is provided with a

temperature-indicating device 52 which is connected by a line 53 to the input side of a main control 54. The main control is of the usual type which receives input signals and by complex pneumatic and electrical circuitry causes output signals to pass to various parts of the steam generating unit ultimately to regulate superheated steam temperature. Located between the fan 51 and the burner 46 is a venturi duct 55 to which are connected lines 56 and 57 which extend to the input side of the main control 54 to transmit to it signals indicative of the load on the unit. The output side of the main control 54 is connected by lines 58 and 59 to a linear actuator such as a cylinder 61 which is connected to the upper vanes 48 of the burner 46 by suitable linkages to regulate the angularity thereof to horizontal. The output of the main control is also connected by lines 62 and 63 to a cylinder 64 which is connected by suitable linkages to the lower vanes 49 of the burner 46 to regulate their angularity to horizontal. The output side of the main control 54 is also connected by lines 65 and 66 to a cylinder 67 which is connected by suitable linkages to the vanes 45 in the recirculated gas inlet 42 to adjust their angularity to horizontal. The output side of the main control 54 is also connected by lines 68 and 69 to a cylinder 71 which is connected by suitable linkages to the damper 44 in the recirculated gas pipe 41.

The operation of the apparatus will now be readily understood in view of the above description. Basically, the main control 54 is operative at high load to direct the gas recirculation inlet vanes downwardly, to throttle the damper 44, and to direct the directional-flame burner downwardly, so that the amount of recirculated gas is low and the line of greatest mass flow of gas through the combustion chamber is adjacent the rear wall; this has the effect of providing the longest path for the products of combustion through the combustion chamber so that the gas temperature when it reaches the convection pass is at a lower value. Such flow also causes the main line of mass flow to be the greatest distance away from the radiant superheater 29. At low load, the main control is operative to direct the recirculated gas vanes upwardly, to open the said gas recirculation damper 44, and to direct the directional-flame burner upwardly so that the amount of recirculated gas is high and the line of greatest mass flow is adjacent the front wall. This means that the mass flow through the combustion chamber takes the shortest path and is closest to the radiant superheater. The general effect, therefore, is to maintain the temperature of superheat at a fairly constant value, any inaccuracies in this control being smoothed out by the operation of the desuperheater 34.

In FIG. 1, which shows the operation at high load, the damper 44 in the pipe 41 is throttled or is near closed position, so that the amount of gas returned to the furnace is low. Furthermore, the gas that is recirculated passes through the inlet 42 and is directed downwardly by the vanes 45. At high load, of course, the volume of air from the forced draft fan 51 is large, as is the fuel which arrives through the fuel gun 47, so that the volume of the mixture of air and fuel passing through the burner 46 and into the combustion chamber is quite large. The fact that the air flow is high and that the load is high is indicated by the pressure drop through the venturi 55 which pressure drop is indicated to the inlet side of the main control 54 through the lines 56 and 57. Generally speaking, therefore, the flame from the burner 46 is dominant and the flow of recirculated gas from the inlet 42 is relatively small, so that the recirculated gas affects the direction and shape of the flame from the burner only to a small degree. This means that the flame is able to move toward the rear wll and proceed up the rear wall where it is forced to take a long path because of the presence of the nose 22. Eventually, this gas passes rearwardly through the gas off-take 19 and downwardly through the front part of the back pass 21 in heat exchange flow with the convection superheater 27. The line of greatest mass flow is not only long but takes place at the rear of the combustion chamber 18 at a considerable distance from the radiant superheater 29; therefore, the amount of thermal energy passed by radiation to that superheater is small. The long path through the furnace means that the gas has a greater opportunity to transmit heat by radiation to the water-walls of the combustion chamber; its temperature when it reaches the back pass and passes over the convection superheater 27 is at a low value. These two factors tend to keep the superheat low. At the same time, of course, it must be understood that the burner 46 is operating at a high heat release value, but the net effect on any given increment of steam is to decrease the heat exchange to that steam and maintain its value load despite the normal tendency of the conventional boiler to have higher steam temperature at high loads. The gas, incidentally, after is passes over the convection superheater, flows rearwardly between the mud drum 25 and the lower end of the baffle 32 and passes upwardly over the back part of the back pass in sinuous flow over the downcomer tubes 24. This reversal of flow causes fly-ash and cinders to be thrown by centrifugal force downwardly into the hopper 39 where they accumulate and can be removed in the usual way. The upper end of the recirculated gas pipe 41, however, resides well above the normal level of fly-ash and cinders in this hopper and, in addition, is protected by the mud drum 25 from such cinders entering the system. It can be seen that this opening at the upper end of the recirculated gas duct 41 is in a quiescent zone in the boiler hidden from ordinary gas flow by the mud drum 25.

Referring to FIG. 2, which shows the operation at low load, it can be seen that the main control 54 has directed the vanes 45 of the recirculated gas inlet 42 in an upwardly direction generally parallel to the inclined portion 36 of the rear wall. The vanes 48 of the burner 46 are directed upwardly and the burners are operating with a low volume of fuel and air passing through them. The recirculated gas damper 44 is maintained in an open position, so that the amount of recirculated gas is large and serves to affect the flame from the burner to a much greater extent than at high load. The flame from the burner, therefore, is forced forwardly almost immediately and passes upwardly adjacent the front wall. It moves upwardly at a rapid rate and the line of greatest mass flow takes a short path in passing from the burner to the convection zone; also, its flow is adjacent the radiant superheater 29. The net effect of these factors is to raise the superheated steam temperature, this having the effect of straightening out the characteristic curve of the temperature of the superheated steam from low load to high load. The greater amount of recirculated gas means that, although the temperature of the gas passing through the convection zone is somewhat lower, the mass flow is greater; since the mass flow dominates the situation, this will tend to raise the temperature of superheated steam. The passage of the line of greatest mass flow of gas close to the radiant superheater 29 provides a considerable increase of heat passing to the radiant superheater by convection, which factor tends to raise the superheated gas temperature.

Another interesting feature of the present steam generating unit is that the recirculated gas coming from the inlet 42 at one side of the lower portion of the combustion chamber and the fuel and air arriving through the burner on the other side have an excellent opportunity to mix, because of the inclined portions 36 and 38 of the walls which provide a narrow outlet from the lower portion of the furnace. In other words, the "bottle" shape of the combustion chamber provides plenty of room for combustion to take place in the lower portion. In passing into the restricted upper portion, the recirculated gas and the fuel-and-air mixture from the burner are thoroughly mixed before passing upwardly, so that one does not

encounter with this boiler variations in temperature from one part of the body of gas to another. Furthermore, the upper portion of the chamber is even further restricted by the presence of the nose **22** which provides a venturi passage for thorough mixing before the gas passes into the convection superheater temperature. This has further effect of leveling the curve of the temperature of gases from one side to another of the furnace before it passes into the convection superheater area. This even distribution of gas temperature from one side to the other of the boiler is beneficial because superheater elements making up the convection superheater **27** are arranged in a series of platens; a considerable problem is presented if the steam emanating from one platen adjacent a side wall, for instance, is different from the steam emanating from a platen in an intermediate position between the side walls.

The use of the inclined portion **36** of the rear wall **14** as one side of the hopper **39** provides an inexpensive furnace construction and provides a very inexpensive method of providing for the recirculation of gas because the hopper area from which the recirculated gas is taken is very close to the inlet **42** located on the vertical portion **35** of the rear wall. The manner in which the duct leading from the forced draft fan **51** to the burner **46** is inclined in a general alignment with the inclined portion **38** of the front wall **13** makes for inexpensive construction, the cost of installing the ducting being maintained at a minimum value. This inexpensive construction is most important in boilers of low and intermediate steam design capacity in contrast to the more expensive high capacity boilers.

Another feature of the invention is the condition of the bottom of the furnace. It will be noted that at high load, where there is no difficulty in maintaining slag in liquid form, so that it flows through the slag tap hole **20**, the recirculated gas is directed toward the slag tap hole and tends to protect it from the direct flame from the burner. This means that the danger of burning out tubes in that area or encountering over-heating problems in the area of the slag tap hole is minimized. On the other hand, at low load, where more difficulty is experienced in maintaining the slag in liquid form, the slag tap hole **20** in the bottom is permitted to be exposed to the flame from the burner, while the recirculated gas moves upwardly and protects the rear wall from slag accumulations and the inclined surface **36** of the rear wall of the furnace.

It can be seen, then, that the various favorable factors of this furnace all operate together at high and low load to provide an inexpensive superheat temperature control system, while at the same time they provide for beneficial furnace performance with a need for relatively little maintenance.

It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such as properly come within the scope claimed.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent, is:

1. A steam generating unit, comprising

(*a*) front, rear, side, roof, and floor walls defining a vertically-elongated combustion chamber, the front wall having a downwardly-directed surface facing and near the floor wall,

(*b*) a convection pass connected to the upper end of the rear wall of the combustion chamber,

(*c*) a radiant superheater mounted in the upper part of the combustion chamber adjacent the front wall,

(*d*) a convection superheater mounted in the convection pass,

(*e*) a directional-flame burner located on the said downwardly-directed surface of the front wall,

(*f*) a gas recirculation means including an inlet located on the rear wall adjacent the floor wall in opposition to the burner, the inlet extending substantially entirely across the wall,

(*g*) adjustable vanes mounted in the inlet to regulate the direction relative to a horizontal plane of flow of recirculated gas into the combustion chamber,

(*h*) a damper disposed in said gas recirculation means for regulating the quantity of recirculated gas which is introduced through the inlet into the combustion chamber,

(*i*) means measuring the temperature of superheated steam and of load,

(*j*) a main control receiving signals from said means, the signals being indicative of superheated steam temperature and of load, and

(*k*) means connected to the main control and operative to regulate the said directional-flame burner, the said adjustable vanes, and the said damper to maintain the temperature at a predetermined value throughout a broad range of load in response to the said signals.

2. A steam generating unit, as recited in claim 1, wherein the rear wall forms one side of the convection pass and a large boiler drum is located in a lower part of the convection pass, wherein means is provided for causing the products of combustion to flow through the convection pass adjacent the upper portion only of the drum, and wherein a recirculated gas off-take is located adjacent the lower portion of the drum.

3. A steam generating unit, as recited in claim 1, wherein the convection pass is provided with a downwardly-depending fly-ash hopper and a recirculated gas off-take pipe extending upwardly from the bottom of the hopper and having an open end located substantially above the normal height of fly-ash in the hopper.

References Cited by the Examiner

UNITED STATES PATENTS

2,851,018	9/58	Heller	122—479
2,856,908	10/58	Koch	122—479
2,926,636	3/60	Paulison	122—479
2,947,289	8/60	Miller	122—479
2,976,858	3/61	Chan	122—479
2,980,082	4/61	Firl	122—479
3,028,844	4/62	Durham et al.	122—479
3,060,906	10/62	Rawdon	122—478
3,060,907	10/62	Blodgett	122—479
3,095,863	7/63	Parmakian	122—479

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