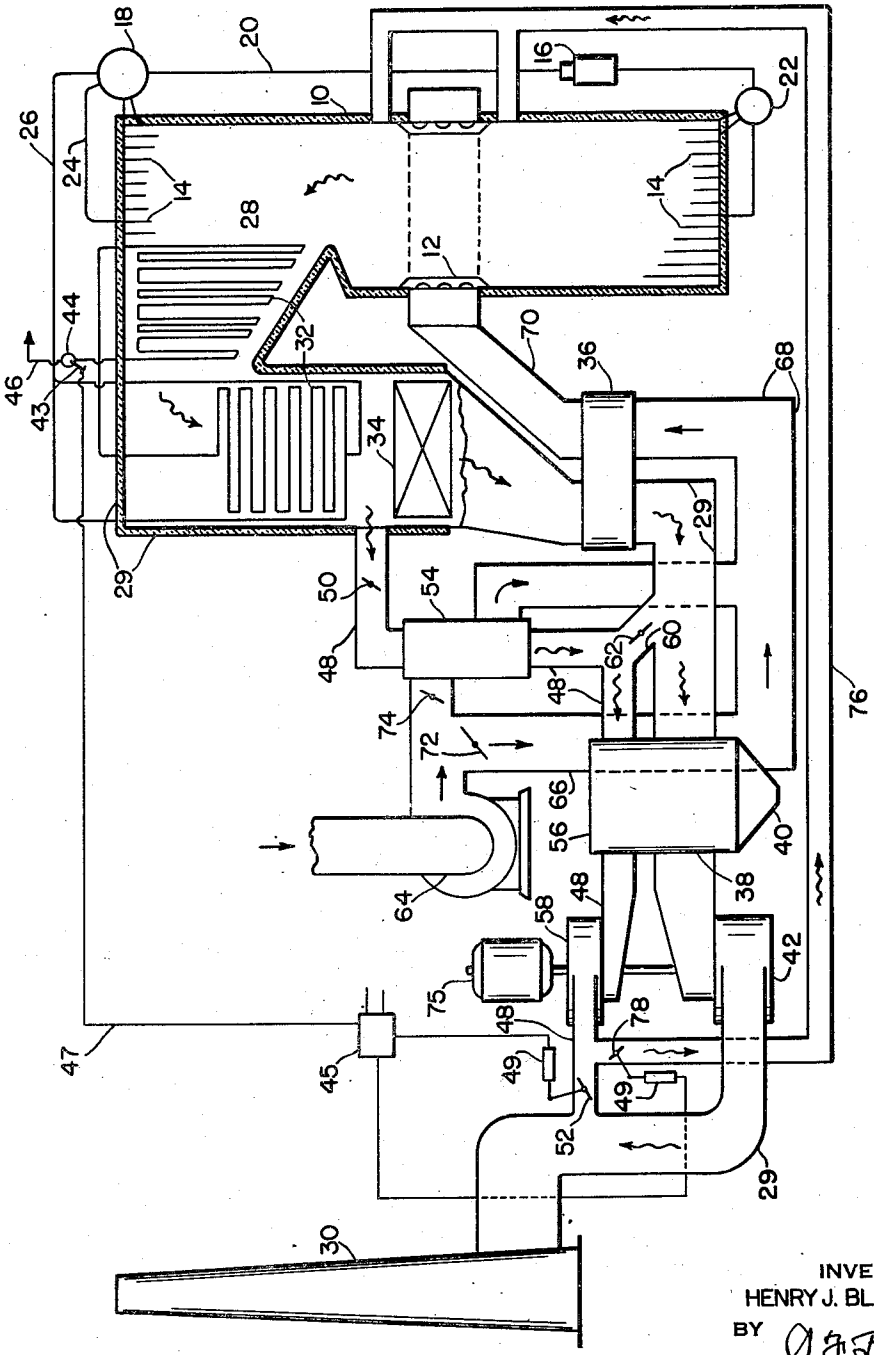
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VAPOR GENERATOR WITH NOVEL GAS RECIRCULATING SYSTEM

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VAPOR GENERATOR WITH NOVEL GAS RECIRCULATING SYSTEM

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This invention relates to vapor generators fired with a suitable fuel and in particular to such generators having means for superheating the vapor generated thereby and means for controllably recirculating combustion gases to control the vapor temperature under certain conditions.

In power plants having steam generators which deliver superheated and/or reheated steam to a prime mover it is necessary that the temperature and pressure of this steam remain substantially constant. This pressure is controlled by regulation of the firing rate of the steam generator with the generator usually being designed to produce the required steam temperature at maximum load when this firing rate is sufficient to meet the maximum load. However, as the load on the generator decreases and the firing rate is accordingly decreased to maintain the steam pressure constant the steam temperature usually falls below the desired value. One method of regulating this steam temperature where the furnace of the generator is lined with steam generating tubes is to recirculate a controlled quantity of the combustion gases leaving the generator back into the furnace of the generator. Where convection and certain types of radiant steam heaters are employed this recirculation has the effect of raising the superheated and/or reheated steam temperature with the greater the amount of gas recirculated, resulting in a higher steam temperature, within limits of course. Thus, in such a steam generator, as the load decreases and the superheated steam temperature falls this temperature may, within limits, be brought back to its desired value by recirculating combustion gas to the furnace with the amount of gas being increased as the load is decreased. In conventional boilers this type of superheat control generally results in lowering the thermal efficiency of the boiler since the combustion gases leaving the boiler and entering the stack usually have a higher temperature than if recirculation were not employed. Furthermore, the over all efficiency of the boiler usually goes down because of the increased draft loss resulting from the recirculating of combustion gases.

In order to recirculate combustion gases it is necessary to raise the pressure of the combustion gases substantially above the pressure within the boiler which has heretofore resulted in the expense of providing a fan entirely separate and in addition to the required induced draft fan or in operating the induced draft fan at a substantially increased pressure thereby increasing the power consumption of the fan.

In certain of the conventional installations for recirculating gas, particularly where a separate fan is required, it is necessary to provide rather elaborate and expensive systems for protecting the recirculation fan from overheating when not in use.

With the system of the present invention these difficulties are greatly reduced or eliminated entirely thereby offering substantial economic advantages and increasing the efficiency of the boiler.

The present invention, in general, comprises a steam

generator or boiler provided with a furnace fired with a suitable fuel and having its walls lined with steam generating tubes. Extending from the outlet of the furnace to the usual stack is a gas pass within which is positioned a steam heater, an economizer, a main air heater for preheating the combustion supporting air supplied to the furnace, a dust collector and an induced fan with these elements being arranged so that the combustion gases pass serially thereof in the order named. Connected in parallel with this induced draft fan is a second fan having its inlet connected with the gas pass both at a location intermediate the air heater and the dust collector and a location intermediate the steamheater and the economizer, with its outlet connected to the gas pass downstream of the induced draft fan. The outlet of the second fan is also connected with the furnace through a suitable gas recirculation duct. Within each of these connections with the inlet and outlet of this second fan is provided individual flow control means and within the connection of the inlet of the second fan with the gas pass at the location intermediate the superheater and the airheater is a heat exchanger which may advantageously be an air preheater connected in series with and located upstream of the main airheater relative to the air flow, thereby being effective to initially heat the air passing through this main airheater at low loads and thus reducing the probability of condensation in the main airheater. At the inlet of the second fan is a second dust collector through which all the gases entering this fan pass. The two fans may be driven by a single motor and each is of such a capacity that neither one is individually capable of handling the large volume of combustion gases generated at maximum load on the boiler but the combined capacities of the two fans is sufficient to handle this volume of combustion gases. This is also true of the dust collectors, the combined capacities of the two collecters being required at maximum load. The control means in the various connections with the second fan are regulated so that this fan acts as an induced draft fan in parallel with the main induced draft fan at high operating loads of the steam generator and acts as a recirculation fan at low operating loads.

It is an object of this invention to provide an improved vapor generating unit of the type having a gas recirculation system for controlling the temperature of superheated vapor generated by the unit.

Other and further objects of the invention will become apparent to those skilled in the art as the description proceeds.

With the aforementioned objects in view, the invention comprises an arrangement, construction and combination of the elements of the generator in such a manner as to attain the results desired as hereinafter more particularly set forth in the following detailed description of an illustrative embodiment, said embodiment being shown by the accompanying drawing wherein the single figure is a diagrammatic representation of a steam generator embodying the present invention.

Referring now to the drawing, wherein like reference characters are used throughout to designate like elements the steam generator depicted therein comprises an upright furnace 10 fired with a suitable fuel, such as pulverized coal, gas or oil, through burners 12 and having the inner surface of its vertical walls lined with steam generating tubes 14. Boiler water is circulated through these tubes by pump 16 which has its inlet connected with steam and water drum 18 through downcomer 20 and its outlet connected with orifice drum 22 from which the water is distributed to the steam generating tubes. The steam and water mixture leaving the upper ends of steam generating tubes 14 is collected in a suitable header or

headers and conveyed to drum 18 through conduit 24. In drum 18 the steam and water mixture passes through a suitable separator with the steam passing out of the upper portion of drum 18 through conduit 26 while the water passes downward through downcomers 20.

The combustion gases generated by the burning of fuel within the furnace 10 pass upward and through furnace outlet 28 with the gases then passing through a suitable passageway designated 29 which leads to the lower end of stack 30. The combustion gases flowing through passageway 29 successively pass through superheater 32, economizer 34, main air heater 36, compartment 38 of dust collector 40 and induced draft fan 42 from which they are conveyed to stack 30.

The steam flowing through conduit 26 from drum 18 passes through superheater 32 and is delivered to header 44 at a predetermined desired temperature and pressure with the steam flowing from this header through delivery conduit 46 to a suitable point of use. While in the illustrative embodiment disclosed the steam generator is provided with the conventional superheater, a reheater may equally well be substituted for the superheater or the generator may have both a superheater and a reheater all as well known in the art.

Connected in parallel relation with economizer 34, air heater 36, compartment 38 of dust collector 40 and induced draft fan 42 is duct 48 which has valve means 50 and 52 at its inlet and outlet respectively. Positioned within duct 48 so that combustion gases flowing through the duct as indicated by the arrows, will pass successively thereover, are auxiliary air preheater 54, compartment 56 of dust collector 40 and fan 58. Communication is established between passageway 29 and duct 48 at a location in each between the airheater and dust collector section disposed therein by means of connection 60 with the flow through this connection being controlled by valve 62. Connected with the outlet of fan 58 is duct 76 which leads to furnace 10, as shown, so that combustion gases may be recirculated to the furnace. Flow through duct 76 is controlled by means of valve 78 disposed therein.

The two fans 42 and 58 are preferably driven by a single motor 75 which need only have sufficient power to handle the volume of combustion generated at maximum load on the boiler.

Combustion supporting air is supplied to furnace 10 at a location adjacent burners 12 by means of fan 64 with the air successively flowing through air ducts 66 and 68, air heater 36 and duct 70 from which it enters the furnace. Connected in bypass relation with air duct 66 is air heater 54 with valves 72 and 74 being provided at the inlet of duct 66 and air heater 54, respectively, to control the flow therethrough.

In operation, when the boiler is operating at maximum or near maximum load, valves 50, 74 and 78 are closed and valves 52, 62 and 72 are open whereby both of the fans 42 and 58 are acting as induced draft fans with combustion gases flowing through passageway 29 and also through connection 60 into duct 48. The boiler is designed to give the proper steam temperature and pressure at maximum load without any gas recirculation being necessary and there is therefore no flow through duct 76 at maximum load or approximately maximum load. As the load on the boiler is decreased however, it becomes necessary to recirculate controlled quantities of combustion gases in order to maintain the superheated steam temperature in header 44 constant. Thus, as the load decreases valves 50, 78 and 74 are moved toward the open position while valves 52, 62 and 72 are moved toward the closed position with the adjustment being such that the pressure at the outlet of fan 58 is increased to a predetermined value above the pressure within furnace 10 and the combustion gas flow through duct 76 is equal to the amount needed to give the required steam temperature in header 44 with the combustion gas flow through air heater 54 being substantially equal to that through duct 76. The rate at which gas is recirculated to the furnace will increase with lowering of the load on the boiler until the point is reached where maximum gas recirculation is required. At this point valves 52, 62 and 72 may be closed and valves 50, 78 and 74 may be completely open. However, it may be desirable even at maximum gas flow through duct 76 to design the system so that valve 52 will be partially open and valve 78 will be partially closed thereby still permitting the combination of these two valves to control the pressure at the outlet of pump 58 and the flow through duct 76.

The rate at which gas is recirculated to the furnace is thus controlled by the adjustment of valves 52 and 78 and this adjustment may be made either manually or automatically with the control being such as to maintain the steam temperature in header 44 substantially constant. In Fig. 1 is a diagrammatic illustration of an automatic control for these valves wherein the steam temperature in header 44 is sensed by bulb 43 and is effective to adjust control mechanism 45 through connecting tube 47. Interconnected with control mechanism 45 are motors 49, one connected to each of the valves 52 and 78, with the control mechanism being effective to regulate these motors, which may be either electric, hydraulic, or pneumatic, so as to properly adjust valves 52 and 78.

Since, in a steam generator operating with induced draft such as that disclosed in the drawing, the pressure within the furnace is subatmospheric and the pressure at the outlet of the induced draft fan is also subatmospheric, or nearly so, and only slightly higher than the pressure within the furnace, it will be understood that in order to recirculate combustion gases to the furnace the pressure of these gases must be raised to a value substantially above the outlet pressure at the induced draft fan in order that the required flow of combustion gases to the furnace may be obtained.

Neither of the individual capacities of fan 42 and 58 is sufficient to handle the large volume of combustion gases generated at maximum load and give the required induced draft necessary for efficient operation of the boiler. However, the combined capacities of these two fans is sufficient for this purpose and as brought out hereinbefore both of these fans operate as induced draft fans at maximum load, with fan 58 acting both as a recirculation fan and an induced draft fan as the load on the boiler decreases and recirculation becomes necessary with the degree to which fan 58 acts as an induced draft fan decreasing as the load decreases and a greater amount of gas recirculation is required with this fan acting entirely or almost entirely as a recirculation fan when maximum recirculation is required. It should be noted that as the load decreases the volume of combustion gases generated also decreases whereby fan 42 is able to handle an increasing percentage of these gases with this fan being able to handle substantially all of the combustion gases that are not recirculated when the load is so low that maximum recirculation is required.

A like relationship applies to the compartments 38 and 56 of dust collector 40. Neither of these compartments is sufficient, per se, to handle the combustion gases generated when the boiler is operating at maximum load but the combined capacities of these two compartments is sufficient to handle these gases, with compartment 56 being sufficient to handle the maximum gas flow through duct 48 and compartment 38 being able to handle the maximum gas flow through fan 42. It is of course necessary to have a dust collector in the system only when pulverized coal is being fired through burners 12.

By arranging fans 58 and 42 in parallel as disclosed and having fan 58 act as the recirculation fan when recirculation is necessary it is not necessary to increase the outlet pressure of fan 42 in order to recirculate gas but this outlet pressure may remain at its normal low value. It is only necessary to raise the outlet pressure

of fan 58 during periods of gas recirculation thereby resulting in an economical operation of the two fans by a single motor.

Since corrosion at the cold end of air heater 36 is apt to occur at reduced loads due to condensation of the combustion gases on the surfaces of the air heater and since gas recirculation is also necessary at low loads the provision of air heater 58 in duct 48 provides a practical arrangement for preheating the air entering the air heater 36 at low loads and thereby insuring against corrosion of this air heater. However, it should be understood that some other type of heat exchange, as for example economizer surface, may be provided in duct 48 in lieu of air heater 54 since this heat exchange is for the purpose of increasing the thermal efficiency of the boiler. As stated hereinbefore in conventional installations it often happens that when gas is recirculated the temperature of the combustion gases entering the stack rises. Thus by by-passing economizer 34 and air heater 36 with substantially the same amount of gas that is recirculated and passing this by-passed gas over heat exchanger 54 the total amount of heat absorbed from the combustion gases will be substantially greater resulting in an increase in thermal efficiency of the unit.

Another result obtained by by-passing the economizer and air heater with substantially the same amount of gases that are recirculated through duct 76 to furnace 10 is to reduce the overall draft loss and consequent power consumption of the system. This becomes clear when it is realized that the draft loss increases as the square of the velocity and power consumption increases as the draft loss and quantity of flow. By by-passing economizer 34 and air heater 36 with the same quantity or substantially the same quantity of gas as recirculated, the velocity of the gases flowing over economizer 34 and air heater 36 is not increased during periods of gas recirculation. Though air heater 54 does of course offer some flow resistance, this flow resistance applies only to the quantity of gas recirculated and power expenditure is substantially less than that which would result if all the gases were passed over economizer 34 and air heater 36, since the passing of all the gases over economizer 34 and air heater 36 would of course result in a substantial increase of velocity and consequently draft loss which would apply not only to the quantity of gas recirculated but to the total of the recirculated gas plus the generated gas.

While I have illustrated and described a preferred embodiment of my novel generator it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. I therefore do not wish to be limited to the precise details set forth but desire to avail myself of such changes as fall within the purview of my invention.

What I claim is:

1. A vapor generator having a furnace, vapor generating tubes lining the inner surface of the walls of the furnace, means for firing said furnace with a fuel, gas pass means conveying the combustion gases generated in the furnace to a point of discharge, a vapor heater disposed in said gas pass means at the beginning thereof and connected to receive and heat vapor generated by the vapor generator, a fan means having a single driving motor, said fan means being comprised of two separate compartments with a fan disposed in each, one of said fans being in series flow with the gas pass means effective to draw the combustion gases through the gas pass means and deliver them to the point of discharge, the other fan being in parallel with said one fan and having its inlet and outlet connected to the gas pass means upstream and downstream respectively of said one fan, the individual capacities of these fans being insufficient to handle the volume of combustion gases produced at maximum load but the combined capacities of these fans is sufficient, means in the outlet connection of said other fan to control the flow therefrom into said gas pass means, a duct leading from said outlet connection at a point upstream of said control means into the furnace of the generator to introduce combustion gases thereinto, means controlling the flow through said duct, and means for regulating said two control means to control the introduction of combustion gases into the furnace to control within limits the temperature of the vapor leaving the vapor heater with the first mentioned control means being moved towards its closed position and the second mentioned control means being moved toward its open position to raise said temperature, and with an opposite control effect being had to lower said temperature.

2. In a steam generator the combination of a furnace, steam generating tubes lining the inner surface of the walls of the furnace, means for firing said furnace with a fuel, a gas pass leading from the outlet of the furnace to a point of discharge, a steam heater disposed within said gas pass and connected to receive and heat steam generated by the steam generator, an induced draft fan in said gas pass effective to draw the combustion gases from the furnace through the gas pass, another fan having its inlet and outlet connected to said gas pass upstream and downstream, respectively, of the first mentioned fan with the inlet being connected to the gas pass intermediate the first mentioned fan and the steam heater and with the individual capacities of the two fans being insufficient to handle the volume of combustion gases produced at maximum load and give the required induced draft but the combined capacities of said fans is sufficient, means for driving said fans, adjustable flow control means in the connection of the outlet of said other fan with said gas pass, a duct leading from the outlet of said other fan at a point upstream of the flow control means into said furnace to introduce combustion gases thereinto, and adjustable flow control means in said duct.

3. The organization defined in claim 2 wherein the capacity of said other fan is but slightly greater than that necessary to recirculate the desired maximum volume of combustion gases to the furnace at the desired maximum pressure.

4. A steam boiler operated with induced draft, comprising in combination a furnace, means for firing the furnace with pulverized coal, steam generating tubes lining the inner surfaces of the furnace walls, a passageway leading from the outlet of said furnace to a suitable point of discharge, a steam heater in said passageway operative to heat steam generated in said tubes and other heat exchange surface in said passageway downstream of said steam heater relative to combustion gas flow, a fan in said passageway downstream of said other heat exchange surface effective to cause flow through said passageway to said point of discharge, a dust collector in said passageway between said fan and said other heat exchange surface, a by-pass around said other heat exchange surface, said dust collector and fan, said bypass having a first inlet connection with said passageway at a location between said steam heater and said other heat exchange surface and a second inlet connection between said other heat exchange surface, means for independently controlling flow through said first and second inlet connections, a heat exchanger in said bypass intermediate said first and second connections, a fan in said bypass downstream of said second connection and effective to cause flow through said bypass toward said stack, a dust collector in said bypass upstream of said fan therein downstream of said second inlet connection, means in said bypass downstream of said fan operative to adjustably control the flow through said bypass, a duct means interconnecting said bypass at a point intermediate the fan and the flow control means with the furnace and means operative to adjustably control the flow through said duct means.

5. The organization defined in claim 4 wherein the in-

dividual capacities of the fans and the dust collectors is not sufficient to handle the volume of combustion gases produced at maximum load but their combined capacities is sufficient.

6. A steam boiler operated with induced draft and having a furnace, means firing said furnace with a suitable fuel, steam generating tubes lining the inner surface of the walls of the furnace, a gas pass leading from the outlet of the furnace to a suitable point of discharge, a steam heater and an air heater successively disposed in said gas pass relative to gas flow, said steam heater being connected to receive and heat steam generated by the boiler, a fan in said gas pass downstream of said air heater effective to draw the combustion gases through the gas pass, another fan in parallel with the first mentioned fan and having its inlet connected with said gas pass at a location upstream of said air heater and at a location intermediate the air heater and the first mentioned fan and having its outlet connected with said gas pass downstream of the first mentioned fan, means for driving said fans, means adjustably and individually controlling the flow through said two connections with the inlet of said other fan, a heat exchanger disposed in the first mentioned connection of the inlet of said other fan with said gas pass, and operative to absorb heat from the gases passing therethrough, means in the connection of the outlet of said other fan with the gas pass operative to adjustably control the flow therethrough, a duct communicating with the outlet of said other fan at a location upstream of the last mentioned means and leading to said furnace, and means in said duct for adjustably controlling flow therethrough.

7. A steam boiler as defined in claim 6 including means responsive to the steam temperature leaving the steam heater and operative to control the flow control means in said duct and in the connection of the outlet of said other fan with the gas pass by opening said means in the former and closing said means in the latter in response to a fall of said temperature and closing said means in the former and opening said means in the latter in response to a rise in said temperature in a manner to regulate the combustion gases introduced into the furnace through said duct in a manner to, within limits, maintain said temperature constant.

8. A steam boiler as defined in claim 6 wherein said heat exchanger is an air heater connected in series with the airheater in the gas pass in respect to air flow.

9. A steam boiler as defined in claim 8 including a bypass for air flow around said heat exchanger and means for controlling the flow of air through the bypass and through the heat exchanger.

10. A steam boiler as defined in claim 6 wherein the individual capacities of the two fans is not sufficient to handle the volume of combustion gases produced at maximum load of the boiler and give the required induced draft for the boiler but the combined capacities of said fans is sufficient.

11. A steam generator operating with an induced draft system and including a furnace, means for firing said furnace with a suitable fuel, steam generating tubes lining the inner surface of the furnace, a passage for combustion gases extending from the outlet of the furnace to a suitable point of discharge, a steam heater disposed in said passage and connected to receive and heat steam generated by said boiler, an air preheater disposed in said passage downstream of said steam heater and adapted to preheat the combustion supporting air of the boiler, an economizer in said passage intermediate said steam heater and said airheater, an induced draft fan in said passage downstream of said airheater, a bypass for combustion gases around said airheater, economizer and induced draft fan, said bypass also having a connection with said bypass intermediate the air heater and the induced draft fan, means for adjustably regulating the flow through this connection and through the entrance of the bypass, a fan in said bypass downstream of said connection, means for driving both of said fans, a heat exchanger in said bypass upstream of the fan therein and intermediate the beginning of the bypass and said connection, adjustable flow control means at the inlet and outlet of said bypass, a duct connected into said bypass at a location intermediate the outlet control means and the fan, said duct leading into said furnace and including means to adjustably control flow therethrough.

12. A steam generator as defined in claim 11 wherein the heat exchanger in the bypass is an air preheater in series with and upstream of the air heater in said passage relative to air flow.

13. A vapor generator comprising a furnace, vapor generating tubes lining a substantial portion of the inner surface of the furnace walls, means firing said furnace with a fuel, a gas pass leading from the outlet of the furnace to a suitable point of discharge, a vapor heater in said gas pass connected to receive and heat vapor generated by the vapor generator and being related to the other heat exchange surface of the generator so as to produce the design vapor temperature and pressure at maximum load, a fan in said gas pass downstream of said vapor heater and effective to draw the combustion gases through the gas pass, another fan in by-pass relation with said first mentioned fan and having its inlet connected with said gas pass at a location intermediate the vapor heater and first mentioned fan, the individual capacities of these two fans being insufficient to handle the volume of combustion gases produced at maximum load and give the required draft but the combined capacities of the fans being sufficient, adjustable flow control means associated with the outlet of the other fan, a duct leading from the outlet of the other fan at a location upstream of said flow control means to said furnace to convey combustion gases thereto, means associated with said duct to adjustably control the flow therethrough, means responsive to the vapor temperature leaving the vapor heater and operative to control these flow control means by opening that associated with the outlet of the fan and closing that associated with the duct in response to a rise of said temperature and closing that associated with the outlet of the fan and opening that associated with the duct in response to a fall of said temperature to regulate the combustion gases introduced into the furnace to maintain said temperature substantially constant.

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