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VAPOR GENERATOR HAVING GAS RECIRCULATION SYSTEM USING GAS EJECTOR

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Sheet 1 of 2

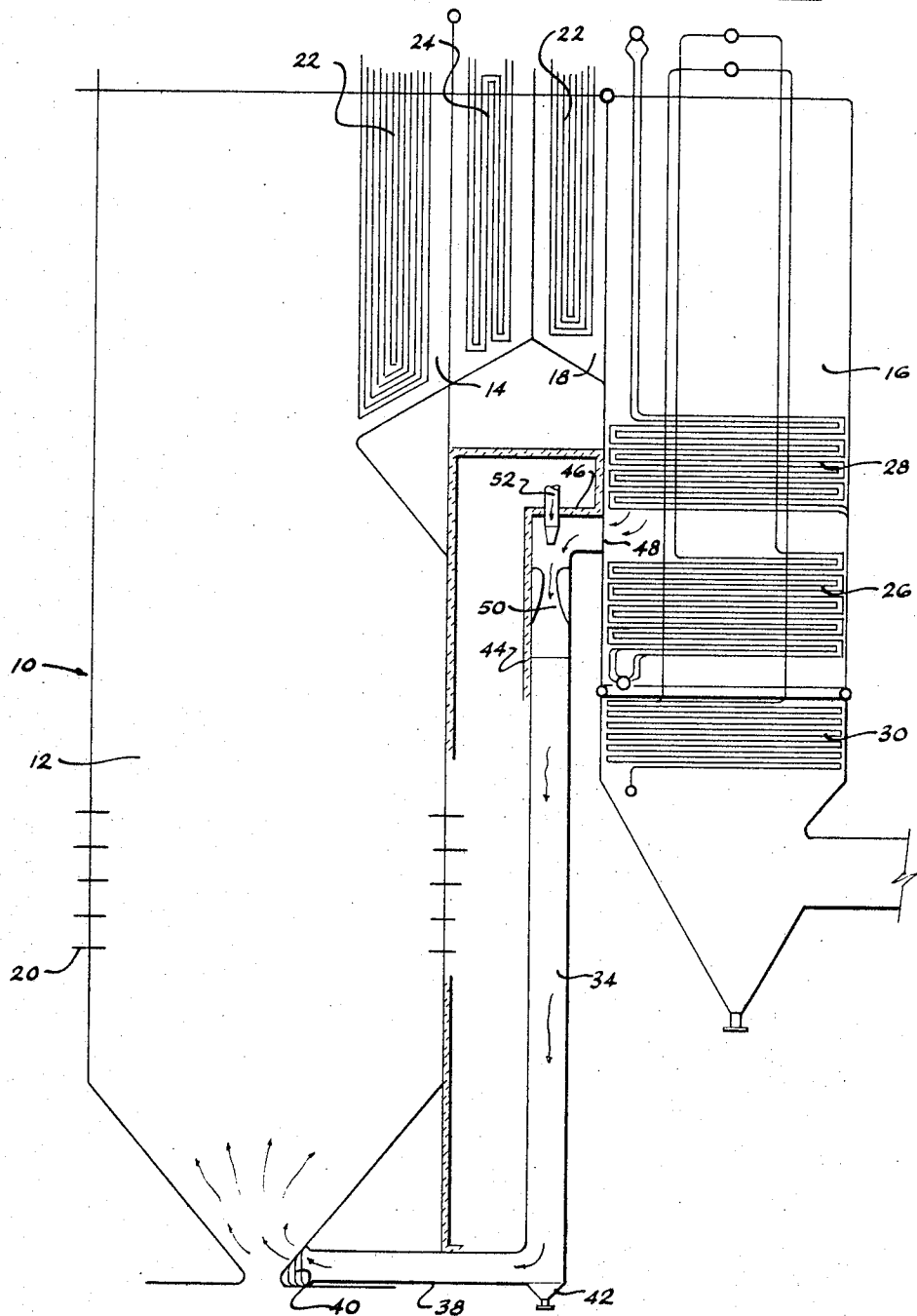


FIG-1

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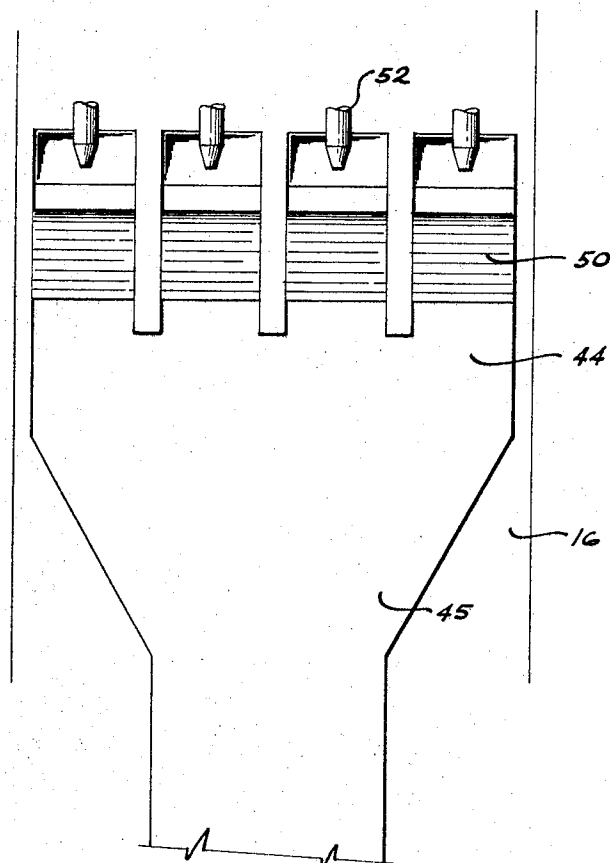


FIG. 2

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VAPOR GENERATOR HAVING GAS RECIRCULATION SYSTEM USING GAS EJECTOR

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2 Claims

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ABSTRACT OF THE DISCLOSURE

A gas recirculation system for a vapor generator having a combustion gas pump in the form of a gas ejector for inducing recirculating flow of combustion gases from the convection heating section of the vapor generator to the furnace.

Background of invention

The invention relates to a vapor generating unit, and particularly to means for effecting the recirculation of combustion gases therein.

In the generation of vapor for producing electricity by means of a turbine, it is necessary to proportion the heat generated by combustion gases in the furnace between the evaporating surface and vapor heating surface since the distribution of heat determines the quantity of vapor generated and the superheat and reheat vapor temperatures. One of the methods employed for distributing heat within a vapor generator involves the recirculation of combustion gases back into the furnace after it is passed in heat exchange relation with heating surface in the gas flow passage. Heretofore such gas recirculation has been effected by means of a recirculating fan disposed to operate in a conduit connected between the point of withdrawal of the combustion gases from the gas passage and the point of readmission of the gases to the furnace.

The use of a fan in a gas recirculation system has several manifest disadvantages. It is a large, cumbersome piece of equipment requiring a considerable amount of floor space for mounting. Oftentimes, sizing of the vapor generator and recirculating fan is such as to prevent the latter's containment within the vapor generator support columns thereby requiring additional building volume to house the apparatus. The fan is a device that employs moving parts and, due to the relatively high gas temperature and volume, it must be capable of handling, it is an expensive apparatus that is subject to increased wear and deterioration thereby requiring downtime for maintenance which adds to its expense. A recirculating fan is also subject to fouling by excessive ash or sediment contained in the combustion gas on which it operates. It is therefore necessary to employ a dust collector as an ancillary piece of equipment to remove such ash and sediment from the gas stream prior to its admission to the fan. Use of a dust collector adds both to the over-all expense of the unit and to the amount of draft loss experienced by the gases which concomitantly increases the pump power necessary to effect their circulation. Moreover, limits are imposed on the temperature of the gases to be handled by a recirculating fan since the use of high temperature metals in its construction to enable it to withstand high gas temperatures would render its use economically unfeasible. It is therefore necessary, where gas recirculation is employed in units having extremely high combustion gas temperatures to insure that as much heat as possible is removed from the gases before they are admitted to the fan. This requires that the gases to be recirculated be withdrawn from the unit after they have been passed in heat exchange relation with all of the heating surface in the convection heating section.

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Since the recirculated gas must pass in heat exchange relation with all of the heating surface, its effectiveness as vapor temperature controlling means is reduced. Firstly, because the gases transfer heat to the economizer before being withdrawn from the convection heating section alteration of the recirculated gas flow, in addition to changing the vapor heating characteristics of the superheater and reheater, will also change the amount of vapor that is produced thereby disrupting the vapor temperature control function. Additional control apparatus must therefore be provided to rectify this situation.

Also, because the gases to be recirculated are caused to transfer heat to both the low temperature superheater and reheater the control of superheat and reheat vapor temperatures are interdependent such that regulation of recirculated gas flow for the purpose of changing one will also effect a proportionate change in the other. This is not always desirable and therefore, added temperature control apparatus such as vapor attemporation, burner manipulation or the like must be employed to reduce the interdependency of the two vapor temperatures.

Summary

According to the present invention the recirculation fan normally employed in gas recirculation systems is replaced by a combustion gas pump in the form of a gas ejector comprising a convergent-divergent nozzle, disposed in the recirculation gas conduit adjacent its connection with the convection heating section of the vapor generator and an air jet for passing air at high velocities through the nozzle. Such a piece of equipment performs essentially the same function as the gas recirculation fan with elimination of the above-mentioned disadvantages. A gas ejector requires only simple ductwork that can easily be contained within the vapor generator support columns so that no additional building structure is required to contain the apparatus. It has no moving parts and is therefore subject to less wear and maintenance requirements. It is also less subject to fouling by sediment contained in the combustion gas and thus requires no ancillary dust collector. The use of a gas ejector instead of a recirculation fan also permits the flow of higher temperature gas through the recirculation line. This feature enhances the unit efficiency of the vapor generator in that the gases need not be caused to pass across as much heat exchange surface to reduce their temperature thereby reducing the draft loss and thus the amount of pumping power required to recirculate the gas. Moreover, the operation with higher temperature gases permits better utilization of temperature control by gas recirculation in that additional heat can be imparted to the temperature regulating surface such as the superheater or reheater without altering significantly the heat input to the economizer.

Additionally, in a power plant operating on a reheat cycle the recirculation gas conduit connection to the convection heating section can be located upstream of the low temperature superheater surface such that control of reheat vapor temperatures by gas recirculation can be affected with little concomitant affect on superheat temperature.

Description of the drawing

FIGURE 1 is a somewhat schematic representation of a vapor generator adapted for use of the present invention; and

FIGURE 2 is a partial side elevation of the vapor generator of FIGURE 1.

Subject of the preferred embodiment

In FIGURE 1 the numeral 10 indicates a vapor generator incorporating the present invention. The vapor generator 10 comprises tubular walls defining a vertically elongated furnace 12 having a heating gas outlet 14 lo-

cated at the upper end of the furnace and a rear gas pass 16 extending vertically downwardly and spaced from the furnace. The rear gas pass 16 is connected to the gas outlet 14 of the furnace by a horizontal gas pass 18. Fuel burners 20 are disposed in a lower portion of the furnace 12 for generating combustion gases that flow upwardly, through the gas outlet 14 and thence through the horizontal and rear gas passes 16 and 18 to a stack (not shown). In flowing from the furnace 12 the combustion gases pass through a convection heating section that includes the horizontal and rear gas passes 16 and 18. In this section is located tubular heating surface that is heated largely by the convection heating characteristics of the combustion gases. In the horizontal gas pass 18 is located the high temperature superheater 22 and high temperature reheater 24. Low temperature superheater 26, low temperature reheater 28, and economizer 30 are disposed in the rear gas pass 16. An ash hopper 32 may be disposed at the end of the rear gas pass for discharging ash from the gas stream leaving the unit.

A gas recirculation system for withdrawing combustion gases from the convection heating section and for reintroducing them into the furnace 12 includes ductwork connected between the rear gas pass 16 and the furnace. The ductwork comprises a vertical conduit 34 disposed in the space 36 between the furnace 12 and the rear gas pass 16. At its bottom end the conduit 34 connects with the bottom of the furnace 12 by means of a horizontal connector 38 that communicates with the furnace through openings 40 formed by spaces between adjacent furnace wall tubes. An ash hopper 42 located at the bottom of conduit 34 is effective to remove some of the ash entrained in the recirculated gases before it is admitted to the furnace. At its upper end the conduit 34 communicates by means of a manifold connector 45 with a plurality of conduit branches 44 that communicate with the convection heating section through connectors 46 connected to aligned openings 48 in the wall of the rear gas pass 16. Within each of the branches 44 is disposed a combustion gas pump in the form of a gas ejector for withdrawing a portion of the combustion gases flowing through the rear gas pass and for passing them through the conduit 34. The gas ejector comprises a convergent-divergent nozzle 50 contained within each branch 44 and an air jet nozzle 52 connected to a source of compressed air (not shown) for discharging a high velocity jet of air across the end of conduit 46 thereby rendering it a suction chamber into which the combustion gases flow from the rear gas pass 16. The gases drawn into the suction chamber are entrained in the air and carried into the nozzle 50 where the velocity energy of the mixture is converted into pressure in a known manner. By means of this arrangement gases can be effectively recirculated from the convection heating section to the furnace. Regulation of the recirculated gas flow can be effected by varying the flow of air through the jet nozzle 52.

Due to the fact that the gas ejector is a significantly smaller piece of equipment as compared to a recirculating fan, it can be constructed of high temperature metals to enable it to withstand high gas temperatures at only a fraction of the cost of so constructing a recirculating fan. Moreover, because an ejector has no moving parts, its operation is much less subject to thermally induced stresses than is a recirculation fan. The result is that a gas ejector can accommodate much higher combustion gas temperatures enabling it to receive gas from the convection heating section from a point upstream of the economizer and, if desirable, upstream of other heating surface where the gas temperatures are normally higher. In the disclosed embodiment the recirculation gas offtake defined by openings 48 is disposed upstream of the economizer 30 and also upstream of another section of tubular heating surface here indicated as being the low temperature superheater 26. Because the offtake is upstream of the economizer 30 the affect of gas recirculation on evaporation is significantly reduced so that changes in gas recirculation

for the purpose of controlling vapor temperatures in the superheater or reheater will not materially affect the amount of vapor being generated. Control of vapor temperature by gas recirculation is therefore more effective. Similarly, in the instant disclosed arrangement because the gas offtake is disposed upstream of the low temperature superheater 26 the effect of gas recirculation on reheat temperature control will have a reduced effect on superheat temperatures.

It will be understood that various changes in the details, materials, and arrangements of parts which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

What is claimed is:

1. A vapor generating unit adapted for operation on a reheat vapor cycle comprising:

- (a) rectangularly arranged walls defining a vertically elongated furnace having a combustion gas outlet disposed at the upper end thereof;
- (b) vapor generating tubes lining the walls of said furnace;
- (c) fuel burning means operative in said furnace for producing combustion gases therein;
- (d) a convection heating section including a rear gas pass communicating with said combustion gas outlet, said convection heating section containing tubular heating surface disposed in said rear gas pass, said tubular heating surface including reheat, superheat and economizer heat exchangers sequentially arranged in said rear gas pass for series flow of combustion gas thereover;
- (e) means for withdrawing at least a portion of the gases through said convection heating section for recirculation through said furnace, said means including:

- (i) a vertically elongated gas recirculation conduit furnace of any tubular heating surface having its upper end communicating with said convection heating section intermediate said reheat and said superheat heat exchangers and its lower end communicating with said furnace at the lower end thereof;
- (ii) a gas ejector nozzle disposed in said conduit adjacent the upper end thereof, and
- (iii) means to supply motor fluid under pressure to said conduit upstream of said nozzle.

2. A vapor generating unit comprising:

- (a) rectangularly arranged walls defining a vertically elongated furnace having a combustion gas outlet disposed at the upper end thereof;
- (b) vapor generating tubes lining the walls of said furnace;
- (c) fuel burning means operative in said furnace for producing combustion gases therein;
- (d) a convection heating section including a rear gas pass communicating with said combustion gas outlet, and containing tubular heating surface disposed in said rear gas pass;
- (e) said rear gas pass being disposed parallel to but spaced from said furnace;
- (f) means for withdrawing at least a portion of said combustion gases from said rear gas pass and for recirculating said gases to said furnace, said means including:
 - (i) means forming openings in the wall of said rear gas pass in facing relation to the space defined between said rear gas pass and said furnace,
 - (ii) means forming openings in the wall of said furnace in facing relation to said space and disposed remote from said combustion gas outlet,
 - (iii) vertically elongated conduit means connected between the openings in the walls of said rear gas pass and said furnace,

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(iv) gas ejector means disposed in said conduit means for assuring withdrawal of combustion gases from said rear gas pass during introduction thereof to said furnace; and
(v) means to supply motor fluid under pressure to said conduit upstream of said gas ejector means.

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U.S. Cl. X.R.