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Brunn

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[54] **STEAM GENERATING SYSTEM AND METHOD UTILIZING EXHAUST GAS RECIRCULATION**

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[52] **U.S. Cl.**..... **110/49 R;** 122/479 A; 431/115

[51] **Int. Cl.**[2]..... **F23J 5/02**

[58] **Field of Search**... 110/49 R; 122/479 R, 479 A; 431/115, 116

[56] **References Cited**

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[57] **ABSTRACT**

A steam generating system and method in which a portion of the exhaust gases from a furnace section is passed through a duct system back into the furnace section to reduce the temperature in the furnace section. Air at ambient temperature is also passed directly into the duct system for cooling the exhaust gases before they are passed to the furnace section.

12 Claims, 2 Drawing Figures

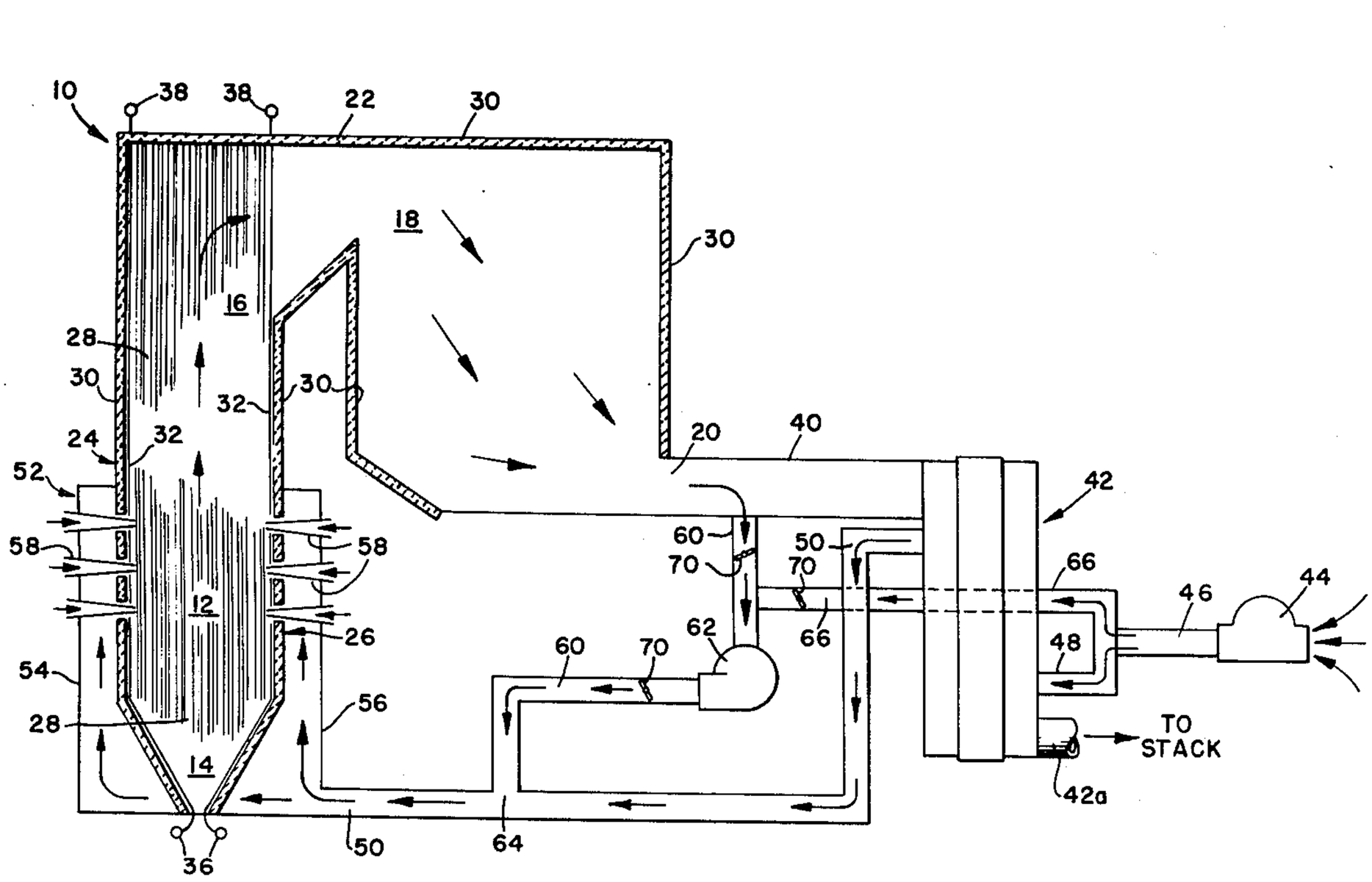

FIG. 2.

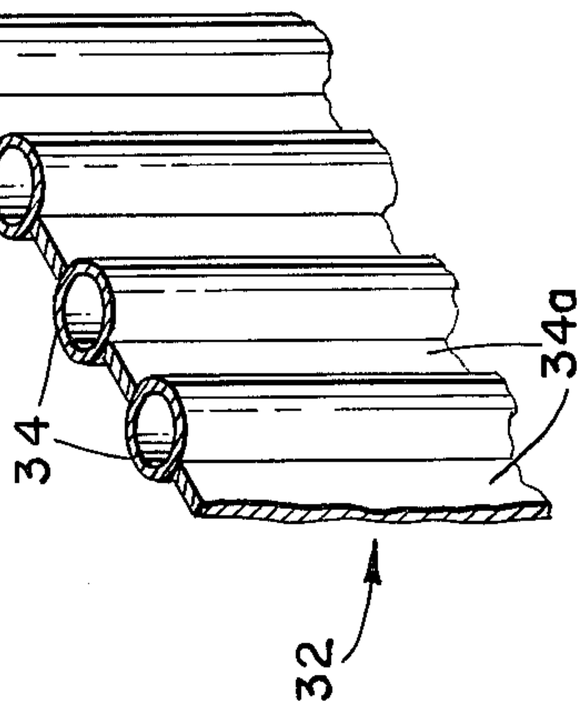
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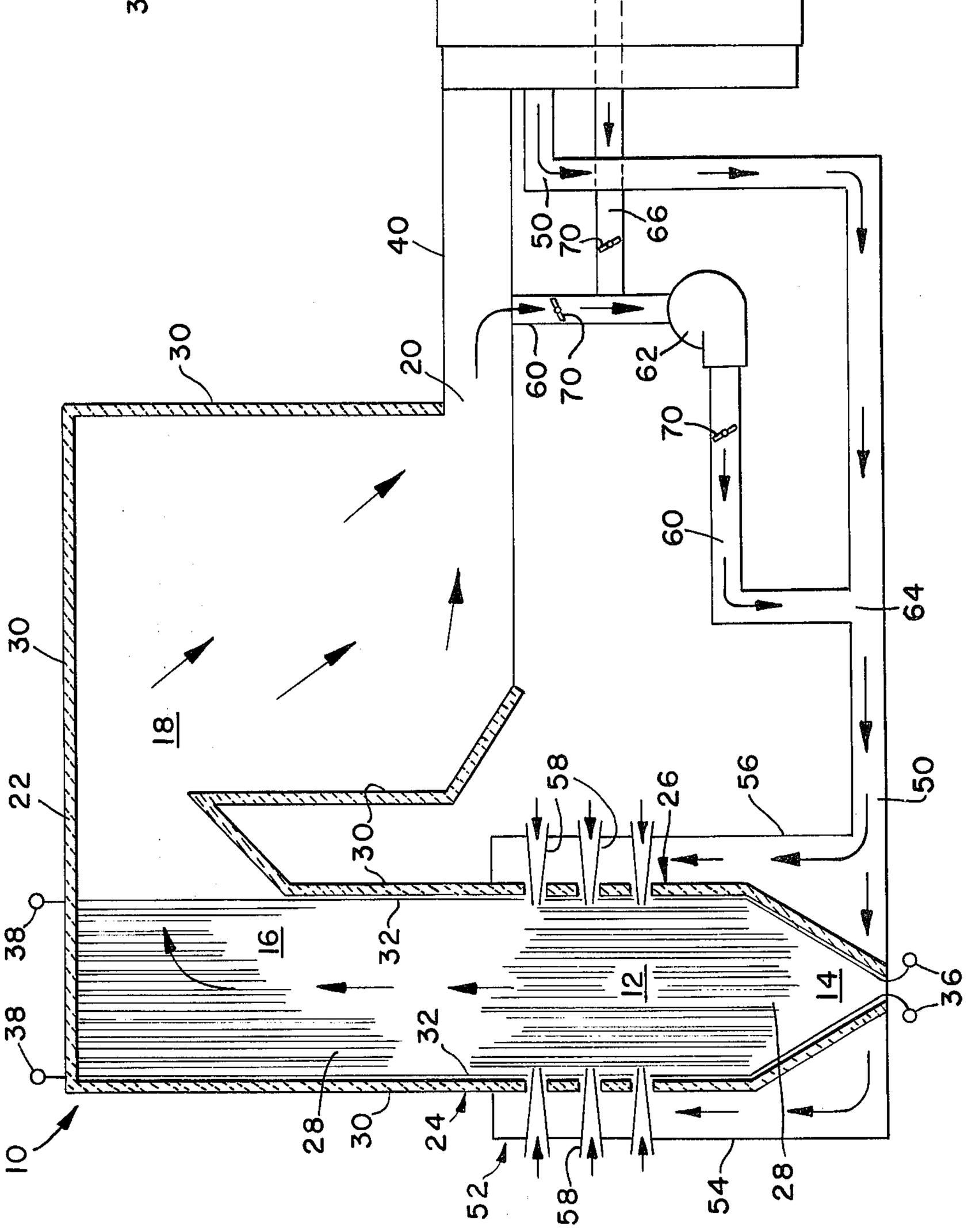
FIG. 1.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STEAM GENERATING SYSTEM AND METHOD UTILIZING EXHAUST GAS RECIRCULATION

BACKGROUND OF THE INVENTION

This invention relates to a steam generating system and, more particularly, to such a system in which exhaust gases from the furnace section of the system are injected back into the furnace section to reduce the temperature in the furnace section.

In the generation of heat in a furnace, such as in the furnace section of a vapor generator, a relatively high concentration of oxides of nitrogen are often formed during combustion in the furnace section and, when discharged therefrom, pollute the surrounding air. Also, when solid fuels are burned, severe slag deposits are often formed on the heat absorption surfaces of the furnace section during operation thereof.

It has been discovered that the formation of nitric oxides and, in the case of solid fuels, slag deposits can be reduced by recirculating a portion of the exhaust gases from the convection section of the generator back into the furnace section, usually in a mixture with the combustion air.

However, it has been proven difficult, and therefore expensive, to handle the relatively hot exhaust gases when transporting same between the outlet of the convection section back to the furnace section. This is largely due to the fact that the temperature of the exhaust gases can be greater than that which fans normally used in this type environment can handle without incurring the risk of damage to the fan. As a result, the system would have to be operated without the fan, in which case the capacity of the system would be severely curtailed, or a much more expensive fan would have to be utilized.

SUMMARY OF THE INVENTION

The present invention is designed to permit the introduction of exhaust gases back into the furnace section yet enable the system to operate at full capacity and permit fans having a conventional operating range to be utilized. Towards this goal, according to the system and method of the present invention, a quantity of air at ambient temperature is injected into the duct connecting the convection outlet to the furnace inlet upstream of the fan disposed in the duct to cool the exhaust gases before they are introduced into the fan and passed into the furnace section.

More specifically, the system of the present invention comprises a furnace section, duct means for passing at least a portion of the exhaust gases from the furnace section back into the furnace section to reduce the temperature in the furnace section, and means for passing air at ambient temperature directly into the duct means for cooling the exhaust gases before they are passed back into the furnace section.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic sectional view of the steam generating system incorporating features of the present invention; and

FIG. **2** is an enlarged, partial elevational view depicting a component of the system of FIG. **1.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The steam generating system and method of the present invention will be described in connection with a vapor generator which is broadly indicated by the reference numeral **10** in FIG. **1** of the drawings. The generator **10** includes a radiant furnace section **12** having a bottom hopper **14** and an upper outlet area **16** to which is connected a horizontally and downwardly extending convection section **18** having an outlet **20,** with a roof **22** extending over the two sections. As a result of this arrangement, hot exhaust gases flow upwardly in the furnace portion **12** through the outlet area **16,** and downwardly through the convection section **18,** whereby they exit through the outlet **20** for further treatment in a manner to be described in detail later.

The furnace section **12** is in the form of an upright rectangular enclosure extending vertically from the floor of the generator and defined by front and rear walls **24** and **26,** and a pair of side walls, one of which is shown by the reference numeral **28.**

It is understood that, in a typical arrangement, a vertical partition wall divides the convection section **18** into front and rear gas passes and that the convection section contains a plurality of superheater tubes, reheater tubes, and economizer tubes. The partition wall and tubes are not shown or described in the present invention since they do not form a part of the present invention, and since they are described in detail in U.S. Pat. No. 3,556,059, assigned to the assignee of the present invention, the disclosure of which is incorporated by reference.

Each of the walls **24** and **26,** the roof **22,** and the walls of the convection section **18** includes an insulating portion **30,** formed by a wall-like structure of a conventional insulating material. The walls **24** and **26** also include a finned tube wall portion **32** disposed immediately within the insulating portion **30.** As shown in FIG. **2,** the wall portion **32** is formed by a plurality of tubes **34** having fins **34***a* extending along their lengths with the abutting fins being welded together so that the enclosures defined by the various walls are substantially gas tight.

Referring again to FIG. **1,** a pair of lower headers **36** and upper headers **38** register with the wall portions **32** of the walls **24** and **26,** it being understood that similar type headers are in registery with the wall portions of the side walls of the furnace section. As a result, water is passed through the lower headers **36** and the tubes **34** of each of the wall portion **32** and is routed in a predetermined flow path by means of suitable downcomers, additional headers, etc., in a manner so that it is gradually turned into steam by virtue of the heat generated in the furnace section **12,** after which the steam is superheated and routed to the upper headers **38** for collection in a conventional manner. Although not shown in the drawing, it is also understood that wall portions **32** can be incorporated in the walls forming the convection section **18** in which case they would function in a similar manner.

A duct **40** is connected to the convection section outlet **20** for receiving the hot exhaust gases passing from the convection section **18** and directing a portion of same into an air preheater **42.** The preheater **42** is provided with an outlet **42***a* for passing the exhaust gases entering therein to a stack, or the like.

A forced draft fan **44** is provided for passing ambient air into a duct **46** having a duct **48** connected to an inlet of the preheater **42.** The preheater **42** operates in a conventional manner to provide a heat exchange between the gases from the duct **40** and the air from the duct **48** to heat the air. The heated air exits from the preheater **42** into a duct **50** which is connected to a wind box **52** located at the lower portion of the furnace section **12.** The wind box **52** functions to supply the preheated air to the furnace section **12** and includes front and rear plates **54** and **56** which are spaced from the corresponding portions of the front and rear walls **24** and **26,** respectively, of the furnace section.

A plurality of burners **58** are supported by the plates **54** and **56** of the wind box **52** and discharge through a plurality of spaced openings formed in the furnace walls **24** and **26,** it being understood that the burners may be arranged in several vertical rows with a plurality of burners in each row. Since the burners **58** are of a conventional design and form no portion of the present invention, they are shown only in general, with it being understood that they include an inlet for receiving fuel, which can be in liquid or gaseous form, or which can be a mixture of pulverized fuel and primary air, as well as an outlet of a reduced cross-section for discharging the fuel into the interior of the furnace section **12** where the fuel is combusted. An annular space is defined between the discharge end portion of each burner **58** and its corresponding opening in the wall **24** for permitting the passage of air from the wind box **52** into the furnace section **12** as will be described later. It is understood that in some installations, overfire ports or the like (not shown) may also be provided through which an additional portion of the air-gas mixture would pass directly into the furnace portion **12.**

A duct **60** connects the duct **40** to the duct **50** for supplying a portion of the hot exhaust gases from the convection section **18** to the duct **50** under the force of a forced draft fan **62** disposed in the duct **60.** As a result, the preheated air from the preheater **42,** and the recirculated exhaust gases from the convection section **18** are mixed in a mixing zone **64** located at the intersection of the ducts **50** and **60.**

According to a main feature of the present invention, a duct **66** connects the duct **46** to the duct **60** for supplying ambient air directly from the fan **44** to the duct **60** upstream of the location of the fan **62.** The air thus mixes with the hot exhaust gases in the duct **60,** to cool the hot exhaust gases before they are passed through the fan **62** and to the mixing zone **64.**

A damper **70** is located in the duct **66** and in the duct **60** both upstream and downstream from the fan **62** to enable the flow rate of the air and gases passing through the respective ducts to be regulated.

In operation, ambient air at ambient temperature from the fan **44** is passed, via the ducts **46** and **48,** into the air preheater **42** and therefore passes in heat exchange to the exhaust gases entering the preheater from the duct **40,** to preheat the air before it exits from the preheater into the duct **50.** The preheated air passes through the duct **50** to the mixing zone **64** located at the intersection between the latter duct and the duct **60.** The duct **60** receives a portion of the hot exhaust gases from the duct **40** and passes same under the force of the fan **62** to the mixing zone **64** where the gases mix with the preheated air in the duct **50** before the resulting mixture is passed into the wind box **52.** The mixture of gases and air is then introduced into the furnace section **12** through the annular spaces defined between the burners **58** and the corresponding openings in the walls **24** and **26.**

Ambient air at ambient temperature from the fan **44** is also passed, via the ducts **46** and **66,** directly to a portion of the duct **60** located upstream from the fan **62** whereby a preliminary mixing of the air and hot exhaust gases in the duct **60** occurs to reduce the temperature of the hot gases before they pass into and through the fan **62** and to the mixing zone **64.** The dampers **70** can be adjusted to control the relative proportions of the exhaust gases and air through the ducts **60** and **66** and therefore control the mixing between the fluids in the duct **60** and at the mixing zone **64.**

As a result of the foregoing, the temperature of the air-gas mixture applied to the fan **62** is relatively low to permit fans having a standard operating temperature range to be utilized.

It is understood that while the present invention is useful in the control of oxides of nitrogen, it is also applicable to steam temperature control and other applications of a gas recirculating fan in steam generators.

It should also be understood that variations may be made in the specific construction and arrangement of the system of the present invention. For example, it is also possible to pass ambient air into duct **66** by means of a separate fan connected to duct **66.** As a further alternative, no fan at all would be needed if the pressure conditions in duct **60** are below the pressure of the ambient air.

Of course, other variations of the specific construction and arrangement of the system disclosed above can be made by those skilled in the art without departing from the invention as defined in the appended claims.

What is claimed is:

1. A steam generating system comprising a furnace, means for passing at least a portion of the exhaust gases from the outlet section of said furnace back into the combustion section of said furnace, said means including a duct connecting said sections and a fan disposed in said duct, means for passing air at ambient temperature directly into said duct upstream of said fan for cooling said exhaust gases before they enter said fan, and means for passing preheated air into said duct downstream of said fan for mixing with said cooled exhaust gases before they are passed to said combustion section.

2. The system of claim **1** wherein said means for passing preheated air into said duct comprises a preheater, means for passing a portion of the exhaust gases from said furnace section to said preheater, means for passing ambient air to said preheater where it passes in heat exchange with said exhaust gases to preheat said ambient air, and means connecting said preheater to said duct.

3. The system of claim **1** further comprising means to pass water in a heat exchange relation to said furnace to convert the water to steam.

4. The system of claim **1** further comprising a plurality of burners cooperating with openings formed in said combustion section of said furnace for combusting fuel in said combustion section, and a windbox extending over said burners, said duct connecting said outlet section of said furnace to said windbox.

5. A steam generating system comprising a furnace, a preheater, first duct means for passing a portion of the exhaust gases from the outlet section of said furnace to said preheater, means for introducing ambient air into said preheater where it passes in a heat exchange relation to said exhaust gases in said preheater to heat said ambient air, second duct means for passing said heated ambient air to the combustion section of said furnace, third duet means connecting said first duct means to said second duct means, a fan disposed in said third duct means for passing a portion of the exhaust gases from said first duct means to said second duct means for mixing with said heated ambient air before passing into said combustion section of said furnace, and means for passing air at ambient temperature directly into said third duct means upstream of said fan means for cooling said exhaust gases before they pass into said fan.

6. The system of claim 5 further comprising means to pass water in a heat exchange relation to said furnace to convert the water to steam.

7. The system of claim 5 further comprising a plurality of burners cooperating with openings formed in said combustion section of said furnace for combusting fuel in said combustion section, and a windbox extending over said burners, said second duct means passing said heated ambient air to said windbox.

8. A method for reducing the temperature in the combustion section of a furnace comprising the steps of passing at least a portion of the exhaust gases from the outlet section of said furnace through a duct and back

into the combustion section of said furnace, passing air at ambient temperature directly into said duct for cooling said exhaust gases, and mixing preheated air with said cooled exhaust gases before they are passed to said combustion section.

9. The method of claim 8 further comprising the steps of passing a portion of the exhaust gases from said furnace section to a preheater, passing ambient air to said preheater where it passes in heat exchange with said exhaust gases to form said preheated air.

10. The method of claim 8 further comprising the steps of passing water in a heat exchange relation to said combustion section of said furnace to convert the water to steam.

11. A method for reducing the temperature in the combustion section of a furnace comprising the steps of passing a portion of the exhaust gases from the outlet section of said furnace in a heat exchange relation to ambient air to heat said ambient air, passing said heated ambient air to said combustion section of said furnace, mixing a portion of the exhaust gases from said outlet section with said heated ambient air before the latter is passed into said combustion section, and cooling said latter portion of exhaust gases before they are mixed with said ambient air.

12. The method of claim 11 further comprising the steps of passing water in a heat exchange relation to said combustion section of said furnace to convert the water to steam.

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