

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO	
RAD: 14-168344- -3	FECHA: 2015-07-28 13:51:41
DEP: 2020 DIRECCION DE NUEVAS CREACIONES	EVE: 378 FASE NACIONAL INCLUIDO CAPITULO I
TRA: 11 PCT-PATENTE DE INVENCION CAPITULOS I Y II	FOLIOS: 6
ACT: 519 TRASLADOINFORME	

DIRECCIÓN DE NUEVAS CREACIONES

2020
Bogotá, D.C.,

Abogado(a)/Señor(a)
LUZ CLEMENCIA DE PÁEZ

Asunto: Radicación: 14-168344- -3
 Trámite: 11
 Evento: 378
 Actuación: 519
 Oficio: 8918
 Folios: 6

Patente de Invención	X			Patente de Modelo de Utilidad	
Vía Nacional					
Vía PCT (Fase Nacional)	X	Capítulo I	X	Capítulo II	
No. Solicitud Internacional	PCT/US2013/023856				
Fecha de Presentación Internacional	30/01/2013				

Como resultado del examen de fondo realizado, con fundamento en el Artículo 45 de la Decisión 486 de la Comisión de la Comunidad Andina, se comunica:

1. Documentos estudiados

Descripción:	Rad. N° 14-168344-00000-0000	01/junio/2014
Reivindicaciones:	Rad. N° 14-168344-00000-0000	01/junio/2014
Dibujos:	Rad. N° 14-168344-00000-0000	01/junio/2014
Prioridades:	US 61/593,556	01/febrero/2012
	US 13/754,030	30/enero/2013

2. Análisis de la Prioridad

Se acepta la reivindicación de prioridad porque ésta solicitud fue presentada dentro del plazo establecido (Art. 9 D 486) y su contenido técnico corresponde con el de la prioridad reivindicada.

3. Objeto de la invención

De acuerdo con lo establecido en el numeral 1.2.2.2 del Capítulo Primero del Título X de la Circular Única para efectos del examen de patentabilidad, se tendrá en cuenta la tasa pagada por el solicitante al momento de comenzar el examen para las reivindicaciones adicionales; esto es que cuando la solicitud contenga más de diez (10) reivindicaciones y no se haya pagado la tasa complementaria, sólo se estudiarán las cubiertas por la tasa pagada. Por lo tanto, se estudiarán las reivindicaciones 1 a 13.

Título de la solicitud: “Banco de economizador de paso dividido con calentamiento de aire con serpentín de agua integrado y derivación del agua de alimentación” (Fl. 1).

El problema planteado en esta solicitud consiste en aprovechar el calor residual resultante en la generación de energía eléctrica, aumentando la eficiencia de la caldera y reduciendo la cantidad de energía calórica descargada a la atmosfera.

Para resolver este problema técnico, la solicitud en estudio proporciona un sistema economizador para una caldera que comprende un banco economizador con una sección e paso fría y una sección de paso caliente, y un calentador de aire con serpentín de agua.

El objeto de la presente solicitud se relaciona con la Clasificación Internacional de Patentes (CIP): F 22 B 31/08.

4. De la solicitud de patente

Reivindicaciones (Art 30 D 486, Art 22 PCT)

El capítulo reivindicatorio no es claro porque:

- La reivindicación 9 y las expresiones: “...para transportar un flujo de gas de chimenea calentado...”, “...la cavidad teniendo una dirección corriente arriba, (...) y una dirección corriente abajo para descargar el flujo de gas...”, “...de manera que cada banco recibe una porción diferente de la corriente de gas de chimenea calentado.”, “...y adaptado para transferir calor desde un flujo (...) de aire con serpentín de agua...”, “...para recibir el flujo de agua de alimentación en el arreglo del economizador desde fuera de la cavidad...”, “...para recibir el flujo de agua de alimentación en el arreglo economizados desde fuera de la cavidad...”, “...adaptada, incluida para controlar la trayectoria del flujo de agua de alimentación entre el economizador de banco de paso frío y el calentador de aire con serpentín de agua; en donde el arreglo del economizador se adapta para canalizar el flujo de agua (...) y fuera del arreglo del economizador.” (reivindicación 1), “...para transportar un flujo de gas calentado, la cavidad teniendo una primera pared lateral del economizador y una segunda pared lateral del economizador; (...) para descargar el flujo de gas...”, “...y en donde el banco de paso frío y el banco de paso caliente (...) de flujo de gas calentado...”, “...y adaptado para transferir calor (...) y desde allí fuera del arreglo del economizador.” (reivindicación 4); describen funciones, efectos, ventajas o resultados a alcanzar, los cuales no son aspectos susceptibles de patente. Para mayor claridad, el producto reclamado se debe definir técnicamente mediante sus características estructurales. Se sugiere al solicitante eliminar la reivindicación y las expresiones citadas.
- Las expresiones: “sustancialmente”, “pluralidad”, “por lo menos” (reivindicación 1, 4, 7, 10), son imprecisas, por lo cual no permiten distinguir la invención del estado de la técnica. Se sugiere al solicitante eliminarlos.

- Las reivindicaciones 4, 6, 7, 8, 10, 11 y 13 no cumplen con lo establecido en el artículo 30 de la Decisión 486 por cuanto carecen de concisión. Lo anterior, debido a que las características incluidas en estas reivindicaciones ya habían sido reclamadas en las reivindicaciones 1, 2 y 3.
- La reivindicación 2 tampoco cumple con lo establecido en el artículo 30 de la Decisión 486, toda vez que no está debidamente soportada, debido a que “una segunda caldera” no esta divulgada en la descripción.

5. Determinación del Estado de la Técnica

El estado de la técnica se determinó con base en la fecha de presentación de la solicitud de prioridad: febrero 1 de 2012, y se encontraron los siguientes documentos que anticipan el objeto de esta solicitud:

Ítem	Documento	Título	Fecha de Publicación
D1	US 2007/0261647	'Multiple pass economizer and method for SCR temperature control'	15/Noviembre/2007
D2	US 2010/229805	'Integrated Split stream water coil air heater and economizer (IWE)'	16/Septiembre/2010

El documento D1¹ divulga un sistema de control de temperatura para mantener la temperatura de salida de fas de gas de un economizador que comprende una pluralidad de configuraciones tubulares que tienen superficies en contacto con el gas (resumen).

El documento D2² divulga un arreglo de calentador de aire de serpentín y economizador para una caldera que comprende una entrada de agua de alimentación para suplir agua a la caldera, y conductos y una válvula para dirigir el agua de alimentación desde la entrada hacia la primera sección de baja temperatura y la segunda sección de alta temperatura (resumen).

6. Examen de Patentabilidad (Art 14 D486)

Nivel inventivo (Art18 D486)

La reivindicación 1 consiste en: “*Un arreglo economizador de caldera que comprende: una cavidad para transportar un flujo de gas de chimenea calentado...*” (Ver página 17 del radicado N° 14-168344-00000-0000).

Comparación de las características técnicas esenciales, con las del estado de la técnica:

Características esenciales	D1	D2
Un arreglo economizador caracterizado por:	Economizador de paso múltiple caracterizado por:	Sistema integrado con calentador de agua y economizador caracterizado por:
Una cavidad que incluye una primera pared lateral y una	Una cavidad (13) que incluye una primera pared lateral y una segunda	Una cavidad que incluye una primera pared lateral y una

1 <https://www.google.ca/patents/US20070261647?dq=20070261647&hl=es&sa=X&ved=0CB0Q6AEwAGoVChMI0c7xijqxlVCs6ACH2KHQnP>

2 https://www.google.ca/patents/US20100229805?dq=2010229805&hl=es&sa=X&ved=0CB0Q6AEwAGoVChMI9Mueg_fpxglVwYMNCh2EZQDm

segunda pared lateral, donde la primera y segunda pared son opuestas entre sí.	pared lateral, donde la primera y segunda pared son opuestas entre sí (Fig. 5).	segunda pared lateral, donde la primera y segunda pared son opuestas entre sí (Figs. 1 a 4)
Un banco economizador que se extiende desde la primera pared lateral del economizador a la segunda pared lateral del economizador, comprendiendo secciones que incluyen un economizador de banco de paso frio y un economizador de banco de paso caliente.	Un banco economizador que se extiende desde la primera pared lateral del economizador a la segunda pared lateral del economizador (Fig. 5), comprendiendo secciones que incluyen un economizador de banco de paso frio y un economizador de banco de paso caliente (1, 2), que se posicionan en paralelo (Fig. 5; Párr. 0032].	Un banco economizador que se extiende desde la primera pared lateral del economizador a la segunda pared lateral del economizador, comprendiendo secciones que incluyen un economizador de banco de paso frio (14) y un economizador de banco de paso caliente (14) (Fig. 6; Párr. [0032]).
Un economizador de banco de paso frio y un economizador de banco de paso caliente se posicionan en paralelo.		No menciona.
El economizador de banco de paso frio y el economizador de banco de paso caliente comprenden cada uno un cabezal de colector y mini-cabezales conectados a cada cabezal colector.	El economizador de banco de paso frio y el economizador de banco de paso caliente comprenden cada uno un cabezal de colector y mini-cabezales conectados a cada cabezal colector (Fig. 6, 8 y 9).	
Un calentador de aire de agua posicionado fuera de la cavidad.	Un calentador de aire corriente abajo posicionado fuera de la cavidad (reivindicación 26).	Un calentador de aire de agua posicionado fuera de la cavidad (Fig. 6; Párr. [0032]).
El calentador de aire con serpentín.	No menciona	El calentador de aire con serpentín (Fig. 6; Párr. [0032]).
Una entrada de agua de alimentación.	Una entrada de agua de alimentación (11) (Párr. [0026]).	Una entrada de agua de alimentación (20) (Fig. 6; Párr. [0032]).
Una salida de agua de alimentación.	Una salida de agua de alimentación (12) (Párr. [0026]).	Una salida de agua de alimentación (Fig. 6; Párr. [0032]).
Una válvula.	Una válvula (5) (Fig. 1 a 5).	Una válvula (26) (Fig. 6; Párr. [0032]).

Los documentos D1 y D2 se consideran el estado de la técnica cercano a la invención definida en la reivindicación 1 porque divulgan sistemas con economizadores.

La diferencia entre la invención, definida en la reivindicación 1 y el sistema de D1 consiste en que el calentador de aire comprende un serpentín.

La diferencia entre la invención, definida en la reivindicación 1 y el sistema de D2 consiste en que el economizador de paso frio y el de paso caliente esta dispuestos en paralelo y que cada economizador comprende un cabezal y mini-cabezales.

El efecto que logra el incluir que el calentador de aire comprenda un serpentín es que optimiza la transferencia de calor entre los dos fluidos.

Por lo tanto, el problema técnico objetivo que pretende resolver esta invención se puede formular así: “cómo modificar el sistema conocido en D1 para optimizar la transferencia de calor entre los dos fluidos”.

Sin embargo, el calentador de aire que comprende un serpentín, ya está divulgada en el documento D2 que se refiere a un calentador de aire de serpentín (Fig. 6; Párr. [0032]).

En consecuencia, la persona del oficio normalmente versada en la materia, incluiría un calentador de aire de serpentín (Fig. 6; Párr. [0032]) del documento D2 en el sistema divulgado en el documento D1 para llegar así al objeto de la reivindicación 1 de la solicitud. Por lo cual se considera obvia.

Asimismo, los documentos antecedentes divulgan las características de las reivindicaciones dependientes así:

- Reivindicación 2: El economizador está conectado a una caldera a través de la línea (36) (D2: Fig. 6).
- Reivindicación 3: En donde el economizador de banco de paso frio es adyacente a una pared lateral del economizador y el banco de paso caliente es adyacente a la otra pared lateral opuesta del economizador (D1: Fig. 2 y 5).
- Reivindicación 5: Un economizador de tubo continuo, donde el economizador de tubo continuo comprende una porción fría con una temperatura de 464°F y una porción de agua caliente 471 °F y posteriormente la temperatura baja a 464 °F (D2: Fig. 6).
- Reivindicación 12: La cavidad es parte de una caldera y en donde la primera pared lateral del economizador y la segunda pared lateral del economizador son directamente opuestas entre sí (D2: Fig. 6)

Las reivindicaciones 4, 6, 7, 8, 9, 10, 11 y 13 fueron afectadas en el numeral 4 de la presente comunicación.

7. Conclusión

Los requisitos de Patentabilidad de la presente solicitud están afectados así:

Ítem	Documento	Reivindicaciones afectadas	Requisito que afecta
D1	US 2007/0261647	1, 2, 3, 5 y 12	Novedad/Nivel Inventivo
D2	US 2010/229805	1, 2, 3, 5 y 12	Novedad/Nivel Inventivo

En cumplimiento del artículo 45 de la Decisión 486 de la Comisión de la Comunidad Andina, se le indica que debe dar respuesta dentro del término de sesenta (60) días contados a partir del día siguiente de la fecha de notificación de la presente comunicación. En caso de no dar respuesta al presente requerimiento, o si a pesar de la respuesta subsistieran los impedimentos para la concesión, se denegará la patente.

Se invita al solicitante se sirva indicar, si así lo considera, su renuncia al término faltante de sesenta (60) días para dar respuesta a este requerimiento y presentarla por escrito.

Finalmente, se le recuerda al solicitante que si como respuesta a este requerimiento llegara a modificar el capítulo reivindicatorio y éste contenga más de diez (10) reivindicaciones, no pagará la tasa de modificación voluntaria pero sí la correspondiente al pago por reivindicación adicional.

Notifíquese el presente oficio conforme a lo dispuesto en el numeral 5.2, literal e), del capítulo quinto del título primero de la Circular Única No. 10 de 2001.



JOSÉ LUIS SALAZAR LÓPEZ
Director de Nuevas Creaciones (c)

El anterior requerimiento fue notificado por fijación en lista, de fecha 2015-08-04

Elaboró: Monica Andrea Gutierrez Almonacid
Revisó: Sonia Andrea Diaz Pirazan



US 20070261647A1

(19) **United States**(12) **Patent Application Publication** (10) **Pub. No.: US 2007/0261647 A1****Albrecht et al.**(43) **Pub. Date: Nov. 15, 2007**(54) **MULTIPLE PASS ECONOMIZER AND METHOD FOR SCR TEMPERATURE CONTROL**(76) Inventors: **Melvin John Albrecht**, Homeworth, OH (US); **James S. Bloss**, Medina, OH (US); **Stephen V. Frascello**, North Canton, OH (US); **Monte J. McGregor**, Canton, OH (US)

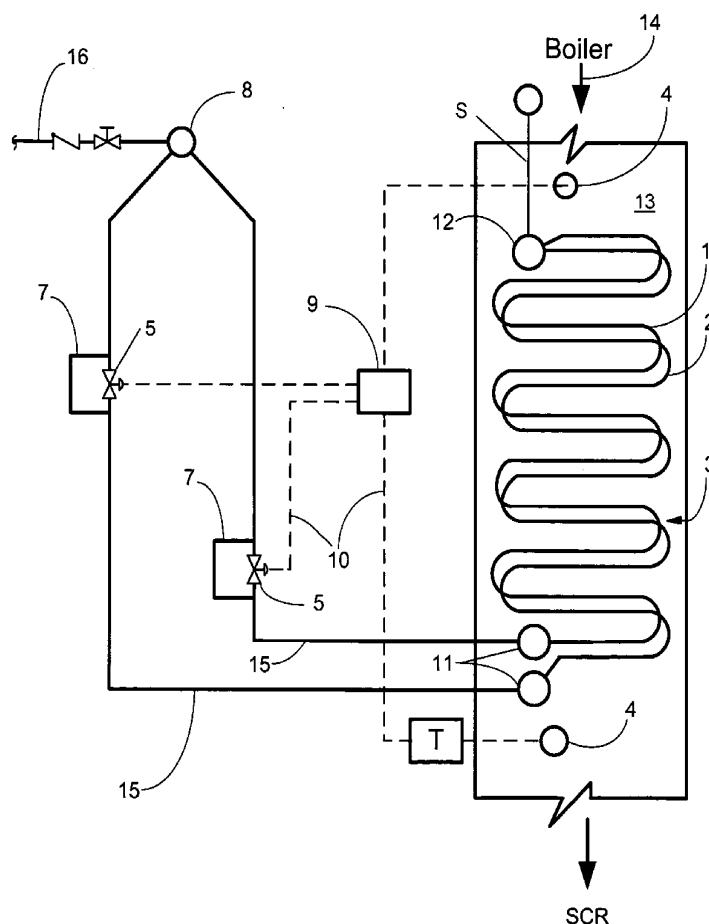
Correspondence Address:

**THE BABCOCK & WILCOX COMPANY
PATENT DEPARTMENT, 20 SOUTH VAN
BUREN AVENUE
BARBERTON, OH 44203**(21) Appl. No.: **11/542,413**(22) Filed: **Oct. 3, 2006****Related U.S. Application Data**

(63) Continuation-in-part of application No. 11/430,761, filed on May 9, 2006.

Publication Classification(51) **Int. Cl.**
F22D 7/00 (2006.01)(52) **U.S. Cl.** **122/406.1**(57) **ABSTRACT**

A gas temperature control system for maintaining a desired economizer outlet gas temperature across a range of boiler loads comprises a plurality of tubular configurations having surfaces that are in contact with the flue gas. Each tubular configuration, preferably, comprises a plurality of serpentine or stringer tubes arranged horizontally or vertically back and forth within the economizer, and each tubular configuration having a separate feedwater inlet. Heat transfer from the flue gas is accomplished by controlling the feedwater flow rates through the tubular configurations. In a temperature control system having two tubular configurations, the overall heat transfer capacity of the economizer may be reduced to maintain the desired economizer outlet gas temperature during low boiler loads by reducing feedwater flow through one tubular configuration and by overflowing the other tubular configuration, such that total flow of feedwater through the economizer is maintained substantially constant. Feedwater flow rate entering the economizer may be used to engage/disengage the economizer water internal proportion or bias system. Once engaged, the measured feedwater flow to the economizer is used to generate a proportioned or biased flow rate demand signal. The demand signal is then compared to the measured underflow proportioned or biased flow rate. If there is a difference between the demand signal flow rate and the measured flow rate, control valve(s) modulating the proportioned or biased flow is/are adjusted.



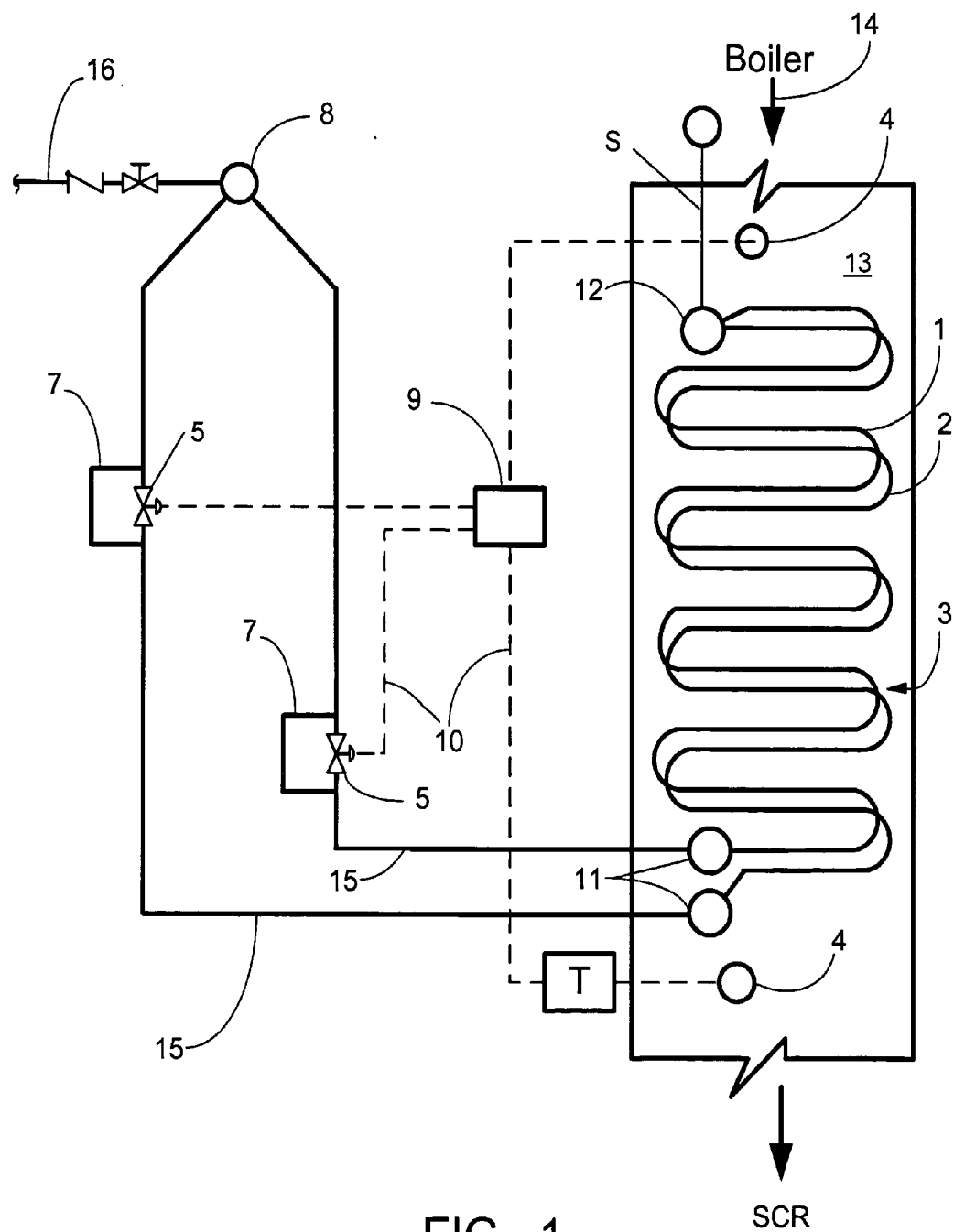


FIG. 1

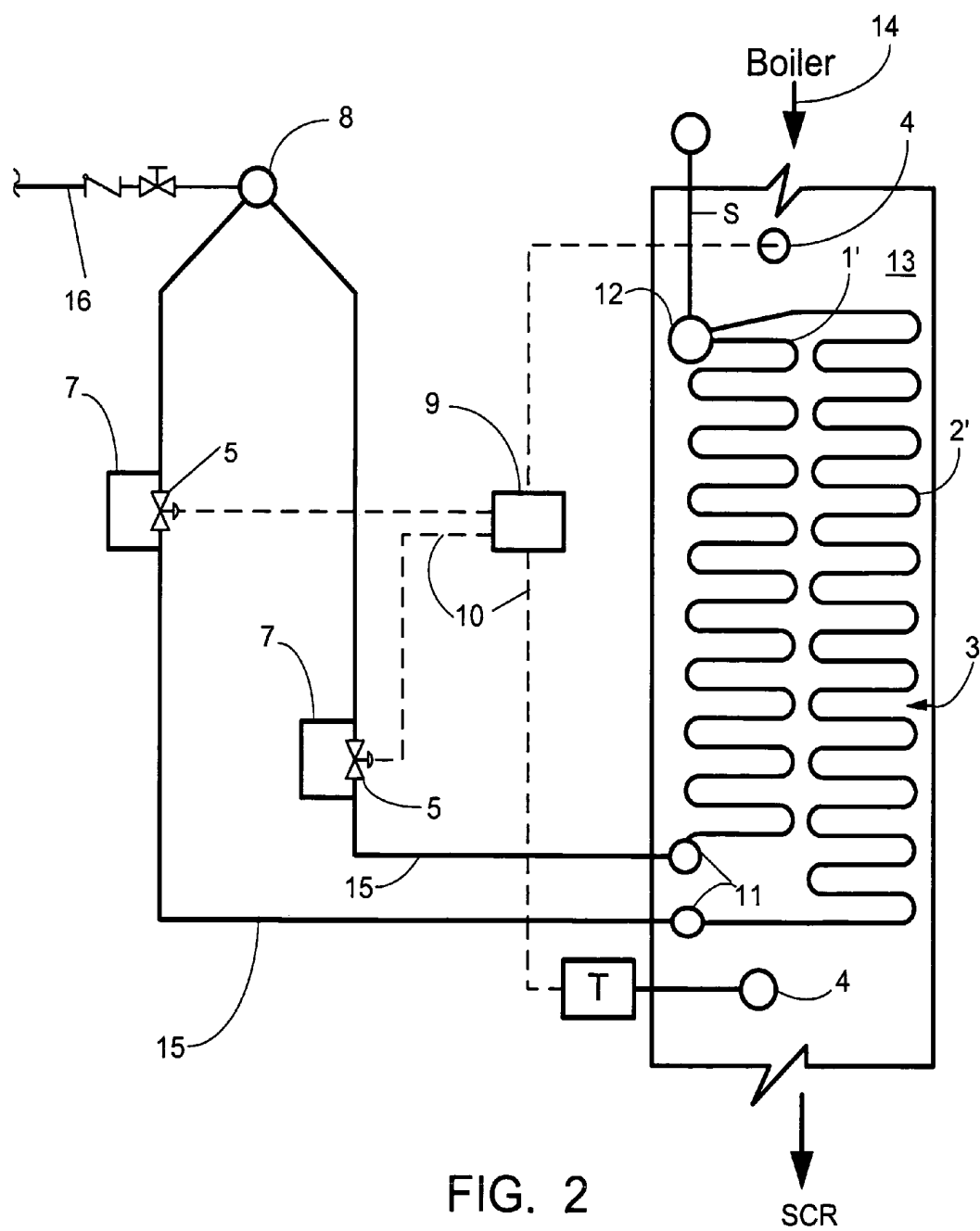


FIG. 2

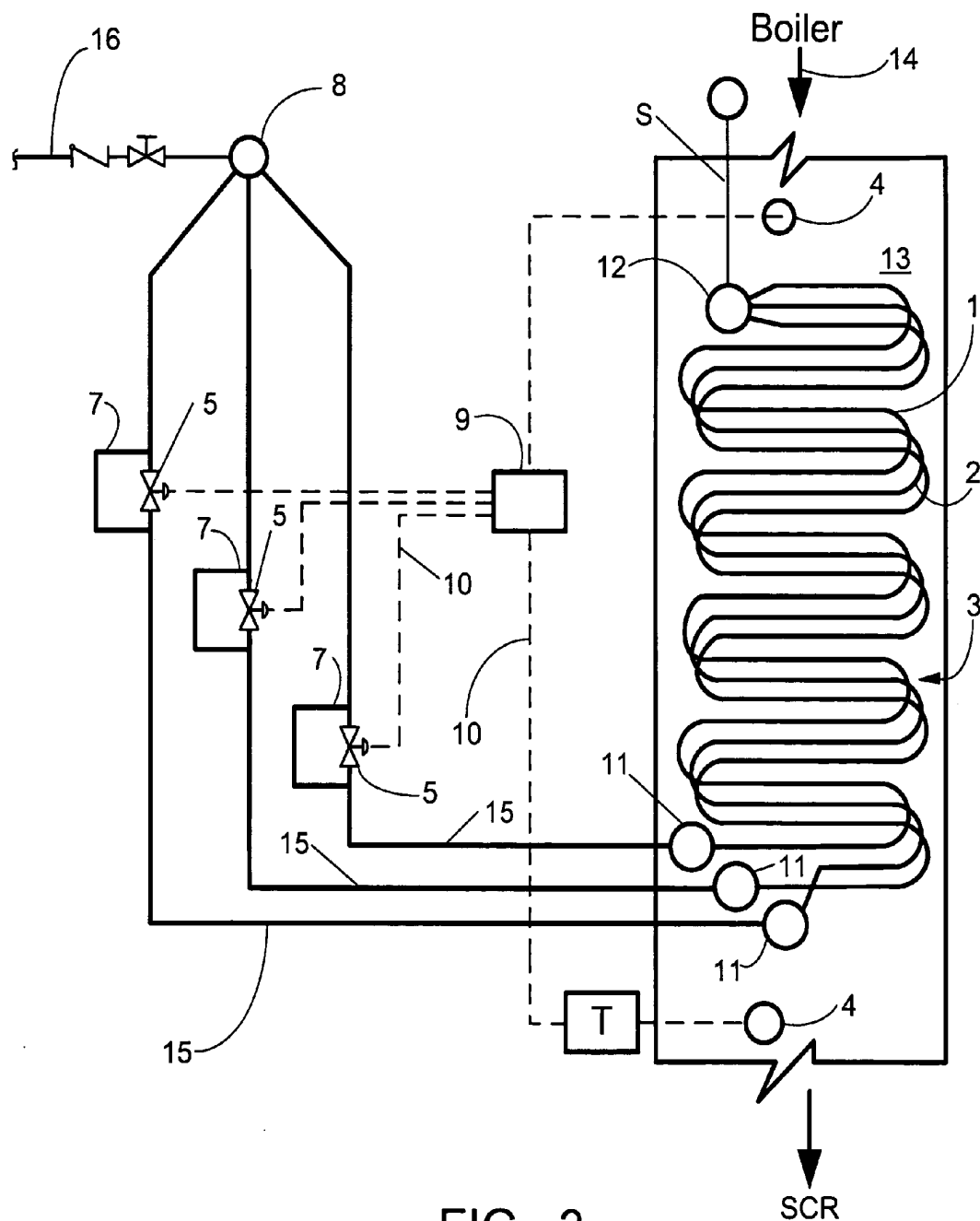


FIG. 3

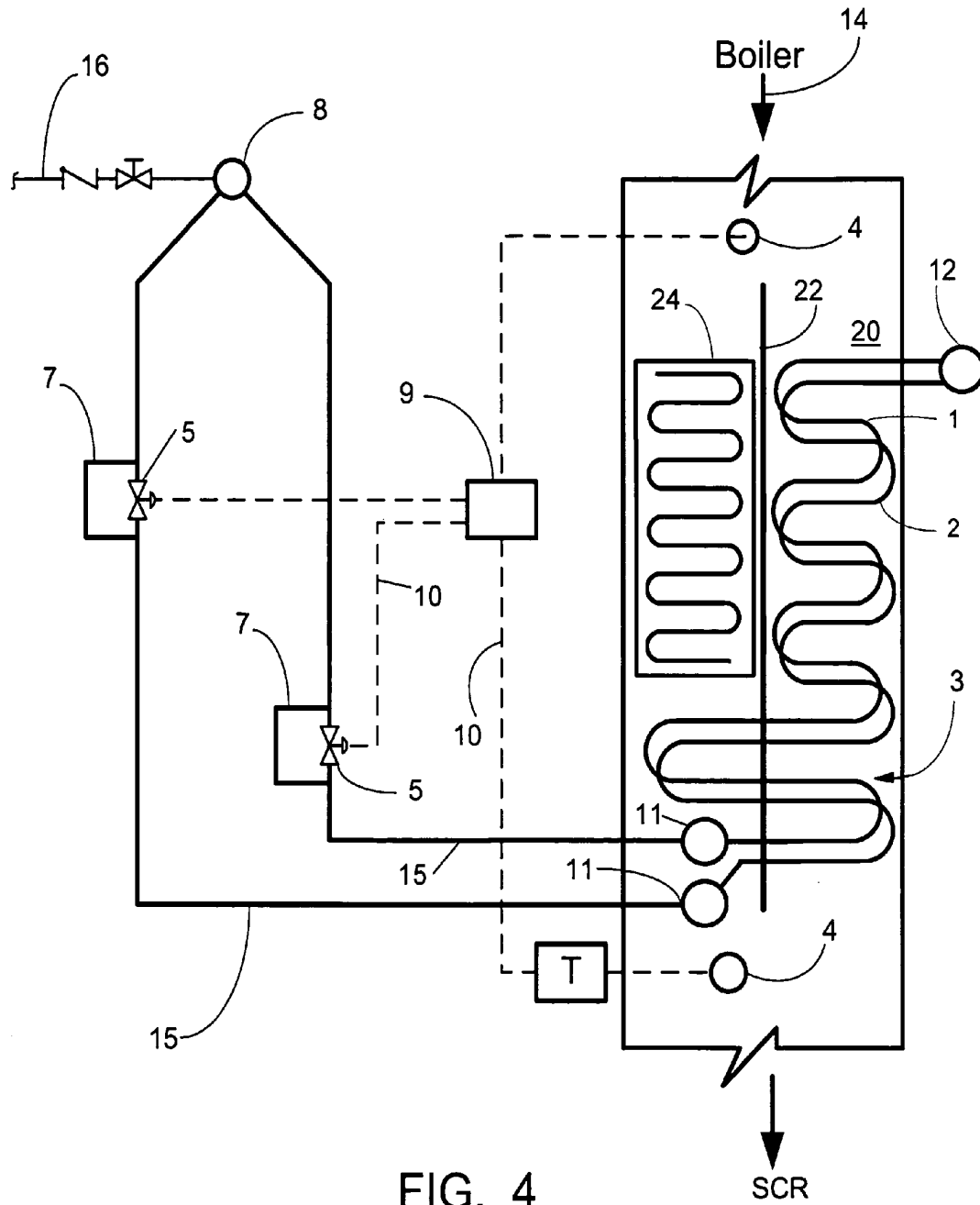


FIG. 4

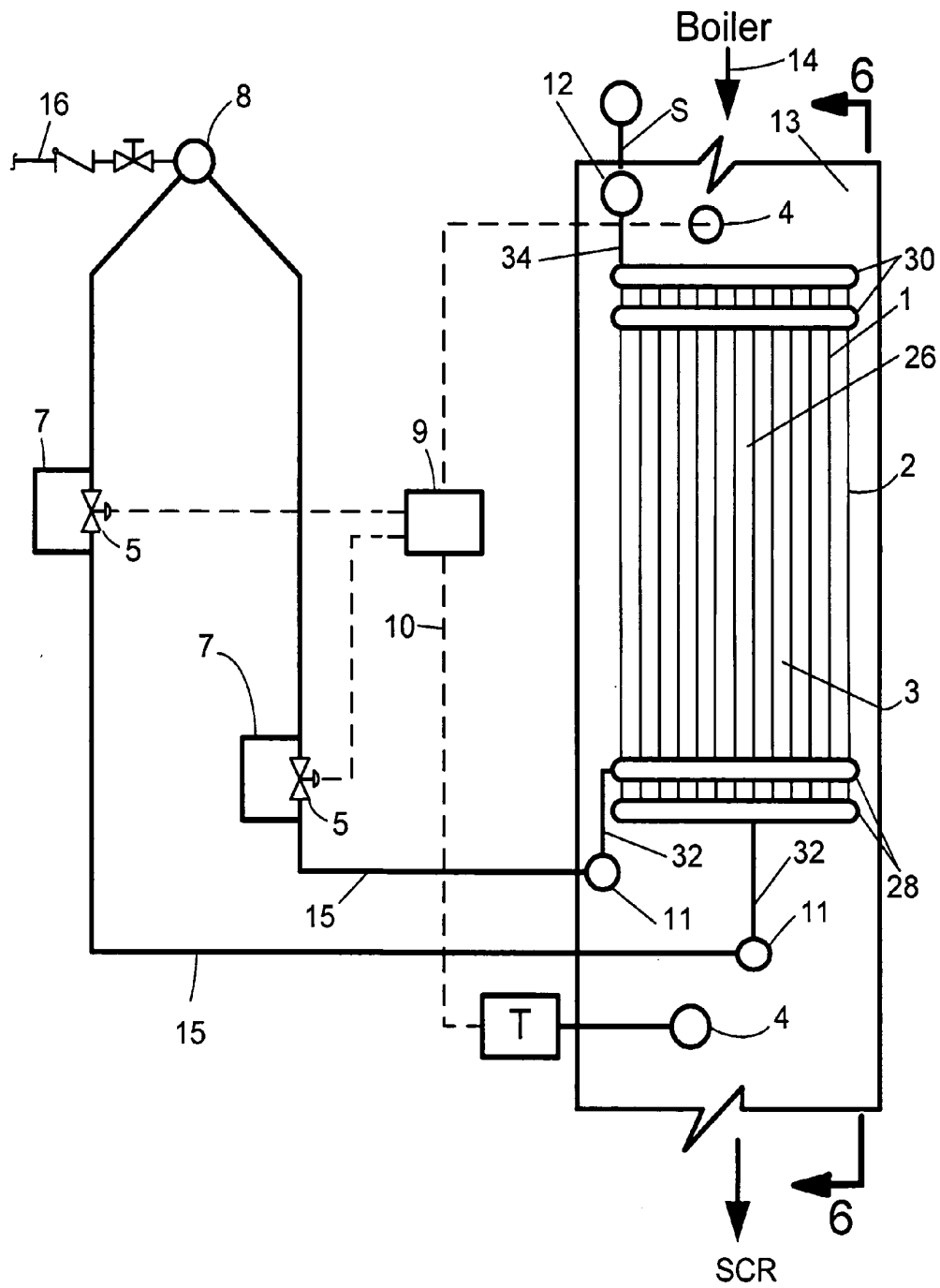


FIG. 5

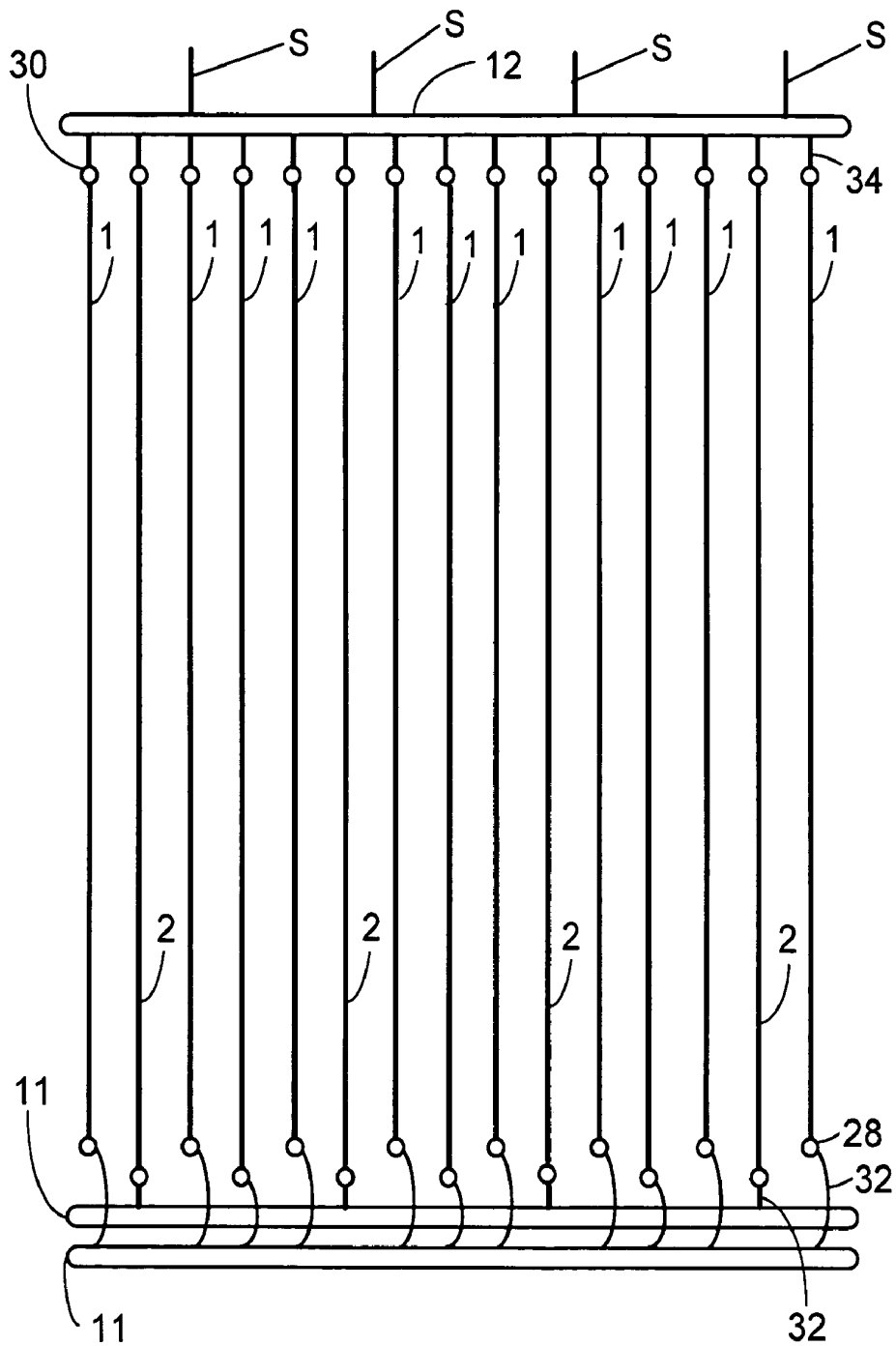


FIG. 6

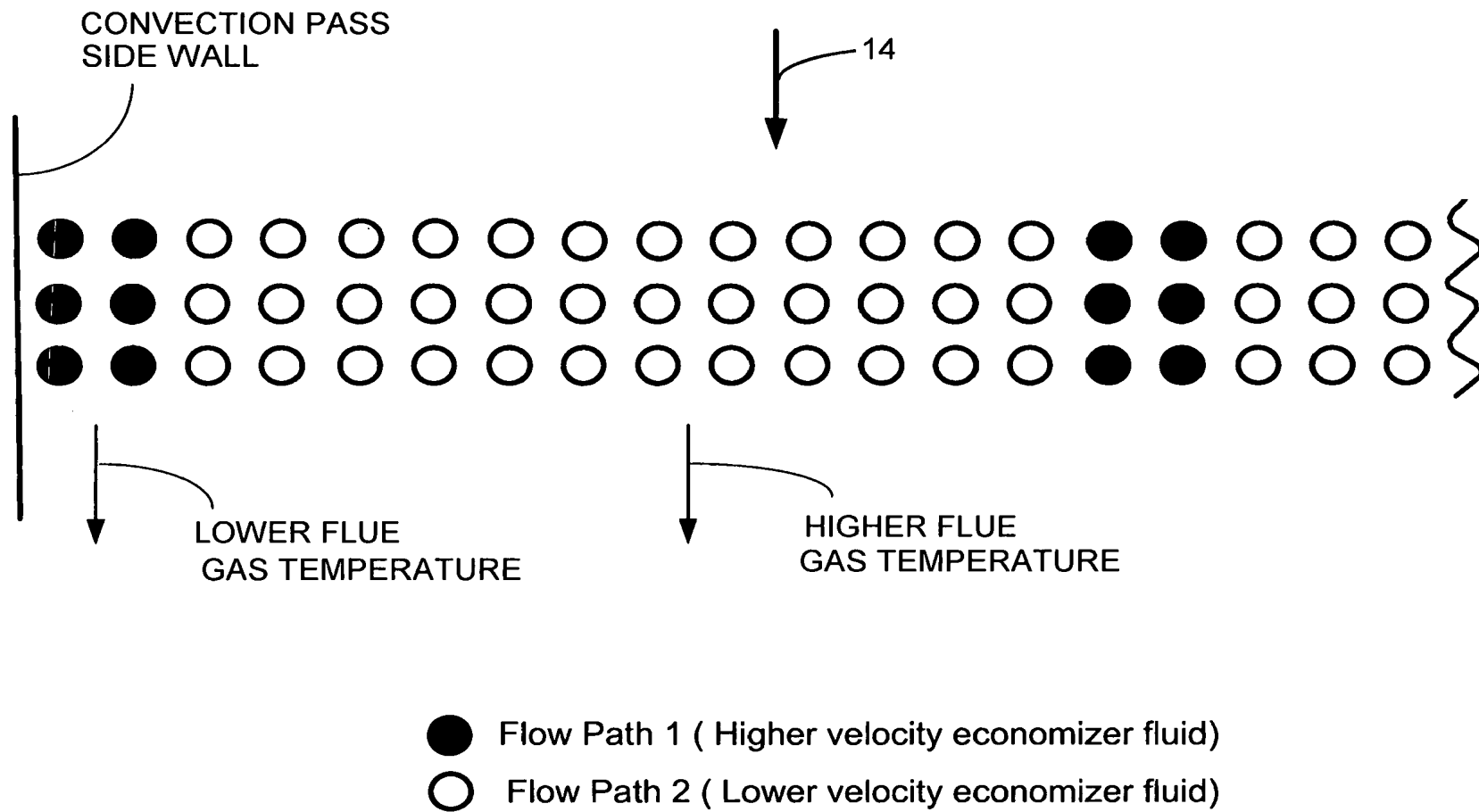


FIG. 7

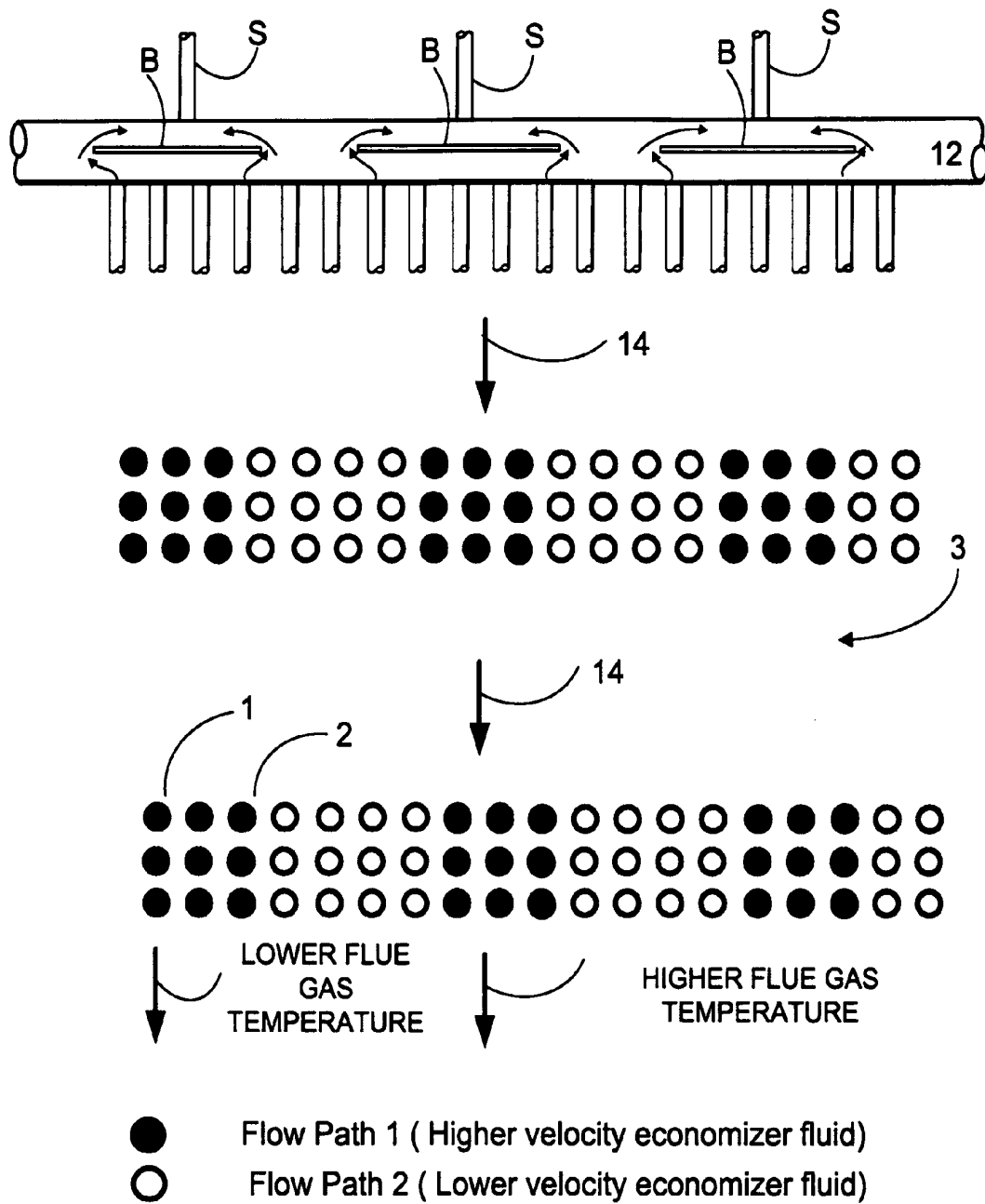


FIG. 8

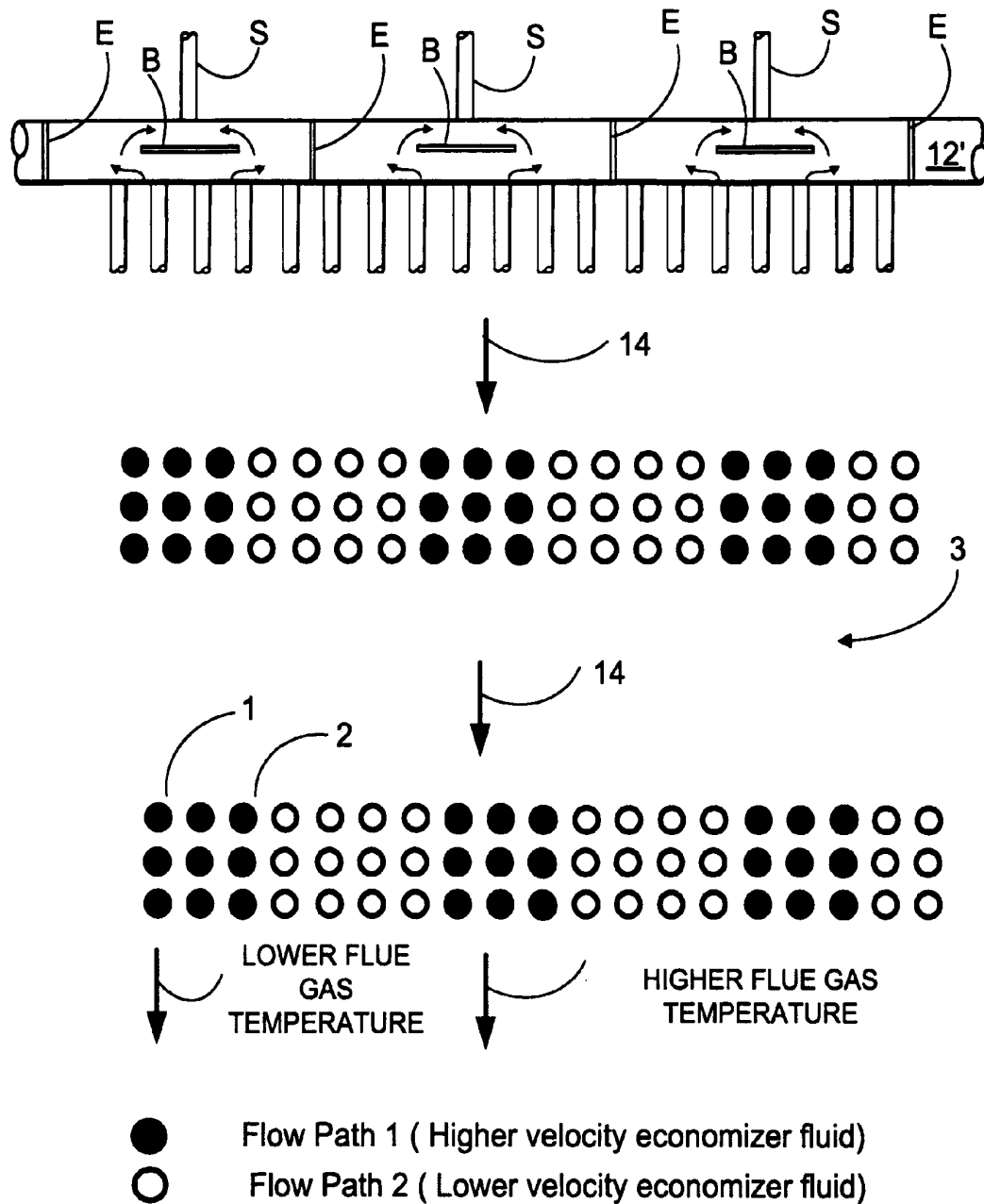
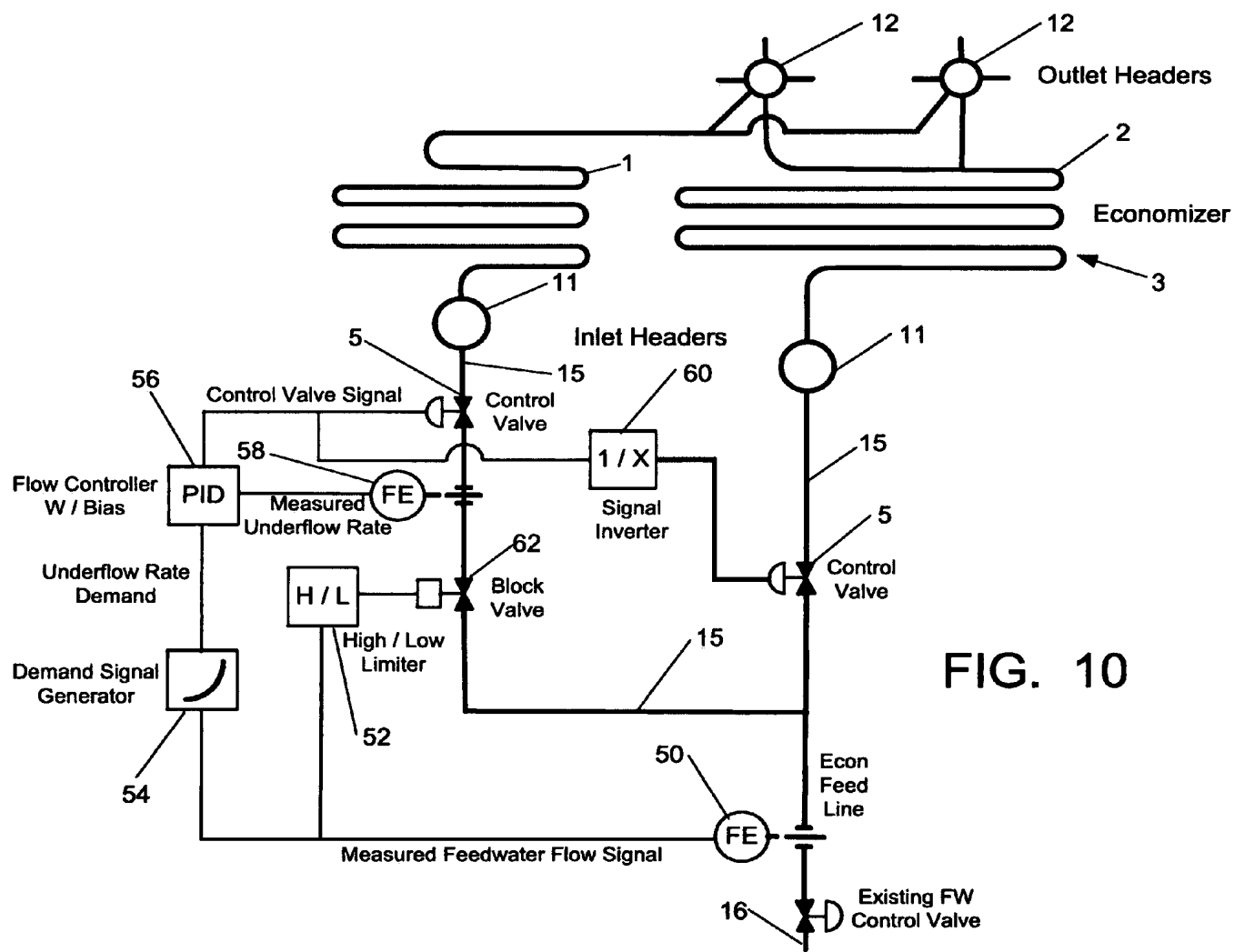


FIG. 9



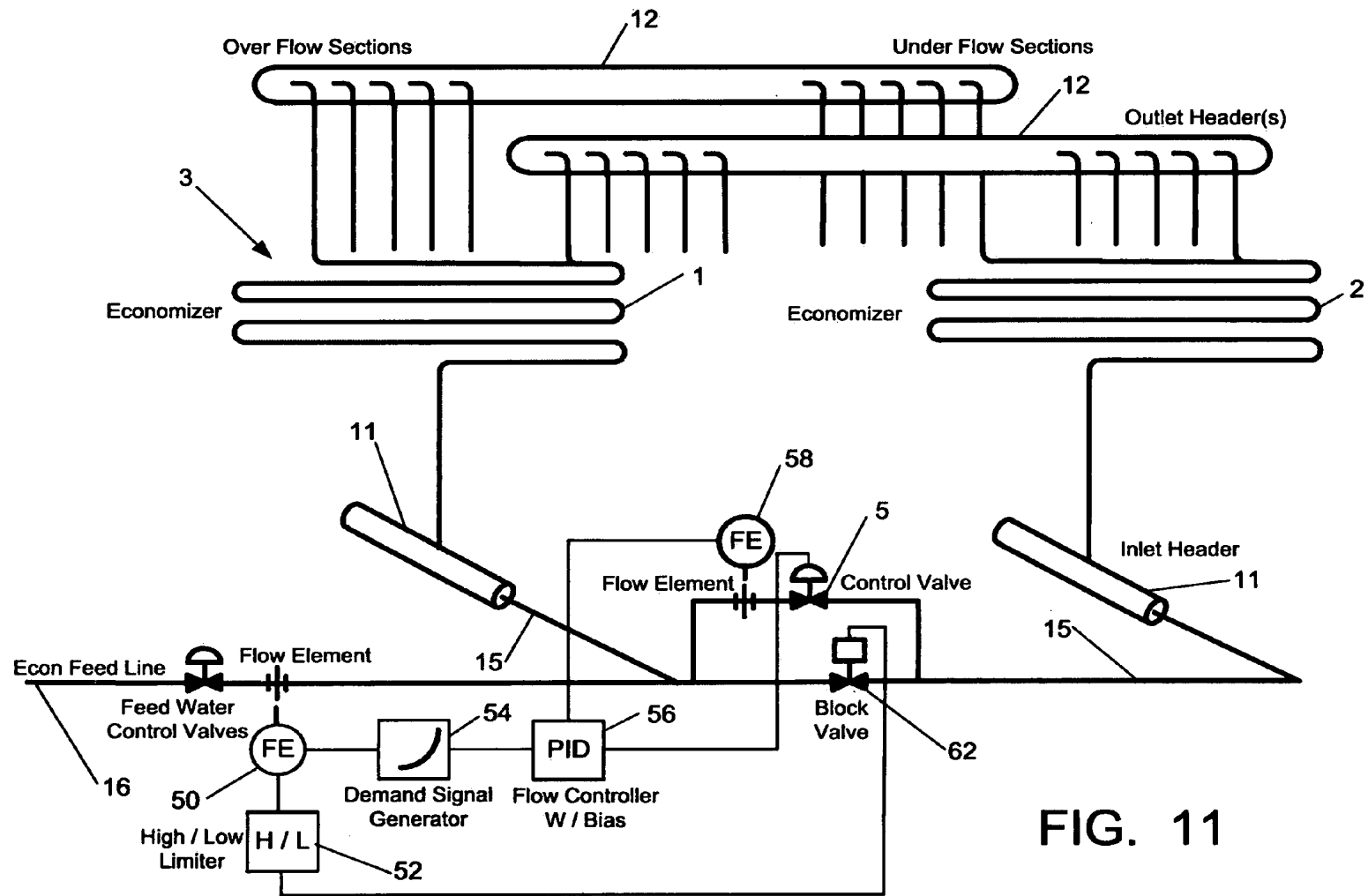


FIG. 11

MULTIPLE PASS ECONOMIZER AND METHOD FOR SCR TEMPERATURE CONTROL

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present invention is a continuation-in-part of U.S. application Ser. No. 11/430,761 filed May 9, 2006.

FIELD AND BACKGROUND OF THE INVENTION

[0002] The present invention relates generally to the field of Selective Catalyst Reactor (SCR) temperature control and in particular to a system and method for maintaining the combustion or flue gas entering the SCR system at or above the optimal catalytic reaction temperature, even when operating the boiler at reduced loads.

[0003] In operating a boiler with a Selective Catalyst Reactor (SCR) system, the effectiveness of the SCR is dependant upon the flue gas temperature entering the catalyst reactor. Most can operate within a temperature range of about 450 degrees F. to about 840 degrees F. Optimum performance may typically occur between about 570 degrees F. to about 750 degrees F. Typically, the desired gas temperature entering the SCR is about 580 degrees F. or greater. At a temperature of about 580 degrees F., the reaction of ammonia with NO_x is optimized and the amount of the ammonia needed for the catalytic reaction is minimized. Therefore, for economic reasons the desired gas temperature entering the catalyst reactor should be maintained within the optimum temperature range of about 570 degrees F. to about 750 degrees F. at all loads.

[0004] However, as boiler load varies, the boiler exit gas temperature will drop below the optimal temperature of about 580 degrees F. To increase the gas temperature to about 580 degrees F., current practice has been to use an economizer gas bypass. The economizer gas bypass is used to mix the hotter gases upstream of the economizer with the cooler gas that leaves the economizer. By controlling the amount gas through the bypass system, a boiler exit flue gas temperature of about 580 degrees F. can be maintained at lower boiler loads.

[0005] With this approach, static mixing devices, pressure reducing vanes/plates and thermal mixing devices are required to make the different temperature flue gases mix before the gas mixture reaches the inlet of the catalytic reactor. In most applications, obtaining the strict mixing requirements for flow, temperature and the mixing of the ammonia before the catalyst reactor is often difficult.

[0006] In another approach to dealing with decreasing flue gas temperature entering a SCR reactor at reduced boiler loads, an economizer was fitted with a feedwater bypass to partially divert the feedwater away from the economizer in order to maintain the flue gas temperature.

[0007] Additional details of SCR systems for NO_x removal are provided in Chapter 34 of *Steam/its generation and use*, 41st Edition, Kitto and Stultz, Eds., Copyright© 2005, The Babcock & Wilcox Company, the text of which is hereby incorporated by reference as though fully set forth herein. Flue gas temperature control using conventional economizers are described in U.S. Pat. No. 7,021,248 to McNertney, Jr. et al. and U.S. Pat. No. 6,609,483 to Albrecht

et al., the texts of which are hereby incorporated by reference as though fully set forth herein.

SUMMARY OF THE INVENTION

[0008] It is an object of the present invention to provide a system and method for increasing the outlet temperature of flue gas passing through the economizer by reducing the water flow in selected tubes and/or sections of the economizer without the need to divert feedwater away from the economizer. When these selected tubes or sections are reduced in flow, the remaining sections or tubes in the economizer are overflowed so that the total flow is maintained through the economizer. To increase the economizer gas outlet temperature, a certain percentage of the tubes in the economizer will have their heat transfer reduced by decreasing the flow through these tubes. The increase in water flow in the remaining tubes has a minimal effect on the heat transfer of the remaining tubes, resulting in an overall decrease in the total gas side heat transfer of the economizer and as a result increases the gas outlet temperature from the economizer.

[0009] It is another object of the present invention to provide a system and a method for maintaining a desired economizer outlet gas temperature across a range of boiler loads by providing two or more sections or compartments of liquid-cooled heat transfer surfaces or tubes in the flow path of the flue gas, wherein the flow rate of each section or compartment is controlled independently of the other sections or compartments, determining the flow rate that is required in each section or compartment in order to produce a combined/overall heat transfer capacity sufficient to maintain the desired economizer outlet gas temperature, and adjusting of the flow rate of each section or compartment of the economizer.

[0010] In one aspect, the system is configured to maintain the flue gas entering a catalytic reactor within a desired temperature range that will promote optimal catalytic reaction, irrespective of the boiler load. Preferably, the flue gas temperature is maintained within a range of about 570 degrees F. to about 750 degrees F., preferably about 580 degrees F. In a normal boiler application, the water side of the economizer is used to cool the flue gas that flows over the surface that is installed in the boiler. The system of the present invention separates the heat transfer surfaces of the economizer to increase the outlet temperature of the flue gases to the desired temperature of about 570 degrees F. to about 750 degrees F., preferably, 580 degrees F. at lower boiler loads. This is accomplished by selectively changing the flow rates through different portions of the economizer. By determining the proper amounts and locations of the heating surface, the desired economizer outlet gas temperature can be maintained within the desired temperature range or at a desired temperature across the desired steam generator load range through the control of the flow rates of water through the different sections of the economizer.

[0011] It is a further object of the present invention to provide a system for maintaining a flue or combustion gas stream being directed into downstream device such as an SCR assembly within a desired temperature range or at a desired (e.g., optimal) temperature comprising: an economizer located upstream of and in fluid communication with the SCR assembly, wherein the economizer comprises at least two tubular configurations having different heat transfer characteristics, disposed in a cross and or counter-current

heat exchange relationship with the flow path of the gas stream generated by a boiler and having a flue inlet and a flue outlet, the boiler being located upstream of and in fluid communication with the economizer, each tubular configuration comprises a feedwater inlet and a feedwater outlet, the outlet of both tubular configurations being attached to an outlet header and the inlet of each tubular configuration being attached to a separate inlet header, and a control system configured to independently control the flow of feedwater through each tubular configuration while maintaining a substantially constant total flow of feedwater through the economizer, the flow of feedwater through each tubular configuration is adjusted in a manner that transfers an appropriate amount of heat from the gas stream to maintain the gas stream at the desired optimal temperature.

[0012] It is a further object of the present invention to provide a method of maintaining a gas stream being directed into a downstream device such as an SCR assembly within a desired temperature range or at a desired (e.g., optimal) temperature, the SCR assembly being located downstream of and in fluid communication with an economizer, the method comprising disposing, within the economizer, at least two tubular configurations in a cross and or counter-current heat exchange relationship with the flow path of the gas stream, the economizer having a flue inlet and a flue outlet, each tubular configuration comprises a feed water inlet and a feed water outlet, the outlet of both tubular configurations being attached to an outlet header and the inlet of each tubular configuration being attached to a separate inlet header, monitoring the gas temperature at the flue inlet or flue outlet, the feedwater temperature at the feedwater inlet and outlet, and the flow of feedwater through the economizer, controlling the flow of feedwater conveyed through each tubular configuration, based on the measured temperatures and flow, to provide the tubular configurations with a combined heat transfer capacity that is effective to maintain the gas temperature at the desired level, wherein the heat transfer capacity of the tubular configurations is decreased by increasing the flow of feedwater through at least one of the tubular configurations and by reducing the flow of feedwater through the other tubular configurations.

[0013] While the present invention is particularly suited to maintaining a desired flue gas temperature entering a downstream SCR device, it will be appreciated that the invention may be used to maintain a desired gas temperature which may be required by other types of downstream devices, and for other purposes. One type of downstream device could be an air heater which typically uses the heat in the flue gas leaving the steam generator to heat the incoming air for combustion. In some cases it is desirable to control the flue gas temperature entering the air heater within a desired range or at a desired temperature above the acid dew point temperature, such as during low load operation, to reduce the possibility of condensation occurring which could form acidic compounds which could lead to corrosion of the air heater. Other types of downstream devices include various types of pollution control equipment; e.g., particulate removal devices such as electrostatic precipitators or fabric filters, and flue gas desulfurization devices such as wet or dry flue gas desulfurization equipment.

[0014] The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and

specific objects attained by its uses, reference is made to the accompanying drawings and descriptive matter in which a preferred embodiment of the invention is illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] In the drawings:

[0016] FIG. 1 is a schematic of a gas temperature control system according to a first embodiment of the present invention;

[0017] FIG. 2 is a schematic of an embodiment of the present invention showing two tubular configurations positioned adjacent one another in a non-overlapping relationship;

[0018] FIG. 3 is a schematic of an embodiment of the present invention showing three tubular configurations positioned adjacent one another in a non-overlapping relationship;

[0019] FIG. 4 is a schematic of an embodiment of the present invention showing application of the invention to a parallel gas path convection pass design;

[0020] FIG. 5 is a schematic of an embodiment of the present invention showing application of the invention to a longitudinal flow economizer, where the concept is applied to control the flow to individual panels of tubes forming the economizer;

[0021] FIG. 6 is a schematic rear view looking into the convection pass of FIG. 5;

[0022] FIG. 7 is a schematic view illustrating a partial rear view of the tubes in the serpentine arrangement of FIG. 1 to show the variations in fluid flow and flue gas temperature resulting therefrom;

[0023] FIGS. 8 and 9 are schematic views illustrating a partial rear view of the tubes in a serpentine arrangement similar to that shown in FIG. 1 to show how variations in economizer outlet fluid temperature due to the variations in fluid flow and flue gas temperature can be accommodated in the outlet headers and supporting stringer tubes; and

[0024] FIGS. 10 and 11 are schematic views of a control system as applied to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] Referring now to the drawings, in which like reference numerals are used to refer to the same or functionally similar elements, FIG. 1 shows an economizer 3 for receiving flue gas generated by a boiler (not shown), located upstream of and in fluid communication with the economizer 3. As used in the present application and as is known to those skilled in the art, the term boiler is used herein to broadly refer to apparatus used for generating steam and may include both drum-type boilers and those of the once-through type. For a general description of such types of boilers or steam generators, the reader is referred to the aforementioned STEAM 41st reference, particularly the Introduction and Selected color plates, and Chapters 19, 20, and 26, the text of which is hereby incorporated by reference as though fully set forth herein. The economizer 3 includes a flue inlet and a flue outlet, and is located in a convection pass 13 upstream of and in fluid communication with a Selective Catalytic Reactor (SCR) assembly (not shown). Within the economizer 3, there is arranged two or more tubular configurations 1, 2 for providing modular heat transfer surfaces for recovery or extraction of heat from the

flue gas. The tubular configurations 1, 2 are preferably disposed in a cross and or counter-current heat exchange relationship with respect to the flow path 14 of the flue gas. It is also contemplated that the tubular configurations may be disposed in a cross and or co-current heat exchange relationship with the flow path 14 of the flue gas.

[0026] Each tubular configuration 1, 2 is attached on one end to an inlet header 11, and on the other end, the tubular configurations 1, 2 may each be connected to a separate (not shown) or to a common outlet header 12, which is supported by stringer tubes S. A feedwater line 15 is connected to each inlet header 11, and on each feedwater line 15 there is preferably provided a control valve 5. Each feedwater line 15 may also include a bypass line 7 installed around the control valve 5 for cleaning or flushing the feedwater lines 15 or the tubular configurations 1, 2, or for performing maintenance on the control valve 5. The feedwater lines 15 are connected to the main feedwater line 16 through a distributor 8. While individual sets of control valve 5 and bypass valve 7 may be installed on each feedwater line 15, it will be appreciated that a single control valve 5, bypass line 7 "pair" which is installed in only one feedwater line 15 may be required. The provision of a control valve 5, bypass line 7 pair on all feedwater lines 15 ensures optimum control of the flow through each of the tubular configurations 1, 2, and may be particularly useful at lower boiler loads, but this degree of sophistication and control may not be required in all applications.

[0027] In one embodiment, each tubular configuration 1, 2 comprises a plurality of serpentine or stringer tubes arranged horizontally or vertically back and forth within the economizer 3. The tubes in one tubular configuration may be positioned in an offset relationship with respect to the tubes of the other tubular configuration. The tubes may be offset vertically, horizontally, diagonally, or longitudinally or offset in a combination of two or more such orientations. Preferably, the tubular configurations 1, 2 are positioned adjacent to one another in the convection pass 13 in an overlapping or non-overlapping relationship, and extend or expand substantially along a flow path 14 of the flue gas passing across the economizer 3. In an alternate embodiment, the heat transfer capacity of each tubular configuration is not identical. It will also be appreciated that the tubes forming the tubular configurations 1, 2 may or may not employ extended surface such as fins to achieve a desired amount of heat transfer to the feedwater flowing through the economizer 3.

[0028] An existing economizer 3 can be modified or retrofitted according to the present invention, such that a selected tubular configuration is fed with sufficient feedwater to effectively reduce the overall heat transfer capacity of the economizer 3. The remaining feedwater is circulated into the remaining tubes in the other tubular configuration. The tubes in the selected tubular configuration would receive more than the normal flow which will slightly increase the heat transfer of this tubular configuration. Also, by determining the appropriate quantity of tubes for each tubular configuration or economizer bank, the effective heat transfer of the economizer 3 can be reduced so that the desired economizer outlet gas temperature is obtained. In FIG. 1, the stringer tubes S that are used to support convective super-heat heat transfer surface (not shown; located above the economizer 3) are shown. In most cases, these stringer tubes S will require the full flow from the economizer 3 because

the gas temperatures increase in the upper regions of the convection pass and the need for cooling would be greater for these stringer tubes S to meet the stress requirement for supporting these additional heat transfer surfaces.

[0029] The temperature monitoring required to adjust the proportioning values of the system can be monitored by knowing the outlet gas temperature or by knowing the inlet gas temperature along with the water side temperatures, both inlet and outlet, and the water side fluid flow through the system. Preferably, temperature and flow rate monitoring, and adjustment of the flow rate in each tubular configuration or economizer bank are carried out by a controller 9.

[0030] In operation, temperature sensors are provided at the flue inlet and/or at the flue outlet 4, at the feedwater inlet and at the feedwater outlet. A flow meter (not shown) is also provided for the main feedwater line to measure the economizer 3 fluid flow through the system. The temperature sensors and flow meter are in signal communication 10 with controller 9 and are calibrated to transmit measurements to the controller 9 for the feedback control of the flow of feedwater through each tubular configuration 1, 2.

[0031] For example, when the controller 9 detects a drop in the boiler load or in the gas temperature at the economizer flue inlet or outlet, the flow of feedwater through each tubular configuration is adjusted to reduce the combined heat transfer capacity of the economizer. This can be achieved by increasing the flow of feedwater through one tubular configuration to decrease the flow and heat transfer of the other tubular configuration.

[0032] FIG. 2 shows the tubular configurations in the economizer positioned adjacent one another in a non-overlapping relationship. The heat transfer of the overall economizer system can be reduced and the desired outlet gas temperature can be obtained by changing the flow rates in the adjacent tubular configurations 1', 2'. In both embodiments, the two different water pathways through the economizer have two different heat transfer characteristics. For example the tube or pathway 1' in FIG. 2 is shorter than the tube 2'. In the embodiment of FIG. 1, the tubes may have different heat transfer characteristic due to different surface treatments of the tubes, different diameters of the tubes, different placement in the gas flow path or different lengths.

[0033] FIG. 3 is a schematic of an embodiment of the present invention showing three tubular configurations positioned adjacent one another in a non-overlapping relationship, and is otherwise similar in concept and operation to FIG. 2. This concept may be particularly useful for controlling gas temperature to prevent it from falling below the acid dew point temperature at which condensation may begin to occur, reducing the possibility of condensation occurring which could form acidic compounds that can corrode downstream devices such as air heaters. Again, while each feedwater line 15 may also include a bypass line 7 installed around its associated control valve 5 for cleaning or flushing the feedwater lines 15 or the tubular configurations 1, 2, or for performing maintenance on the control valve 5, it will be appreciated that a control valve 5, bypass line 7 "pair" does not need to be installed in each feedwater line 15; in a three tubular configuration arrangement, a control valve 5, bypass line 7 pair need only be supplied on two of the three tubular configurations. This arrangement may again be particularly useful at lower boiler loads, depending upon the degree of control desired.

[0034] In addition, under certain low flow conditions, it may be necessary to provide orifice means at one or both of the inlets and outlets of individual tubes in a given tubular configuration to provide additional pressure drop for flow stability in these tubes. Orificing these tubes, particularly the lower velocity flow paths, provides additional pressure drop which will tend to equalize the flow distribution between each of the tubes in that tubular configuration.

[0035] FIG. 4 illustrates application of the principles of the present invention to a parallel gas path convection pass design. The parallel gas paths in the convection pass 20 are established by a baffle 22 as is known to those skilled in the art. As shown therein, the economizer 3 may have a lower portion which extends across both of the parallel gas paths, while an upper portion may reside only in a single one of the parallel gas paths. Opposite the upper portion of the economizer 3, in the other gas path, may be provided steam cooled surface, such as superheater or reheater surface 24. The baffle 22 may or may not extend into the lower portion of the economizer 3, and may be steam or water cooled surface depending upon the flue gas temperatures.

[0036] FIGS. 5 and 6 are drawn to an embodiment of the present invention as applied to a longitudinal flow economizer, where the concept is applied to control the flow to individual panels 26 of tubes forming the economizer 3. The individual panels 26 of tubes are provided with panel inlet headers 28 and panel outlet headers 30. Feedwater from the economizer inlet headers 11 are fed to the panel inlet headers 28 by means of supply tubes 32. Feedwater flow through the panels 26 and is collected at the panel outlet headers 30. Feedwater is then conveyed from the panel outlet headers 30 via riser tubes 34 to the economizer outlet header 12.

[0037] FIG. 6 is a schematic rear view looking into the convection pass of FIG. 5, viewed in the direction of arrows 6-6 of FIG. 5. It is understood that while two tubular panel configurations 1, 2 are shown, an additional third tubular panel configuration flow path could be employed as well.

[0038] FIG. 7 is a schematic view illustrating a partial rear view of the tubes in the serpentine arrangement of FIG. 1 to show the variations in fluid flow and flue gas temperature resulting therefrom. The tubes comprising flow path 1 (higher velocity economizer fluid) are denoted by solid dark circles, while the tubes comprising flow path 2 (lower velocity economizer fluid) are denoted by open circles. The higher velocity economizer fluid tubes extract more heat from the flue gas passing across these tubes, and as a result the flue gas temperature leaving these banks of tubes is lower than the flue gas temperature leaving those banks of tubes which have a lower economizer fluid flow there-through.

[0039] FIGS. 8 and 9 are schematic views illustrating a partial rear view of the tubes in a serpentine arrangement similar to that shown in FIG. 1 to show how the variations in economizer 3 outlet fluid temperatures due to the variations in fluid flow and flue gas temperature can be accommodated in outlet headers 12, 12' and supporting stringer tubes S. As before, the tubes comprising flow path 1 (higher velocity economizer fluid) are denoted by solid dark circles, while the tubes comprising flow path 2 (lower velocity economizer fluid) are denoted by open circles. In some economizer arrangements, the economizer outlet header may be a continuous header 12, with a single common interior portion, where feedwater heated by the various tubular configurations in the economizer 3 is collected and

then dispersed via the stringer tubes S. While theoretically the economizer feedwater may travel anywhere along the length of this outlet header 12, in practice the feedwater travels the shortest route from the tubular configurations feeding the outlet header 12 into the nearest adjacent stringer tubes S. This type of economizer outlet header is schematically illustrated in FIG. 8. In other types of economizer arrangements, the economizer outlet header may be formed of a plurality of separate, shorter headers which are then field girth welded together at their ends E to make the entire economizer outlet header. In this type of economizer outlet header, designated 12' and schematically illustrated in FIG. 9, the feedwater can only be conveyed into and out of the interior portions of each separate header, the ends E of each header preventing fluid flow into adjacent separate headers. It will thus be appreciated that fewer tubular configurations supply feedwater to these separate headers and fewer stringer support tubes S convey feedwater from these separate headers. Significant temperature differences between the temperature of the fluid within the stringer tubes S are to be avoided since such temperature differences can lead to differential thermal expansion of the stringer tubes S. In order to encourage mixing of the hotter and cooler feedwater fluids entering either type of economizer header 12 or 12', a baffle means B may be employed to encourage mixing of the hotter and cooler feedwater streams within the headers 12, 12' prior to the feedwater exiting into the stringer support tubes S, thereby equalizing the temperatures within the stringer tubes S. The baffle means B may be a simple plate located to cause the feedwater flow to divert as desired, or it may be a more complex structure such as a perforated plate with holes sized and/or spaced in a particular configuration.

[0040] While two types of economizer outlet headers 12, 12' are shown in FIGS. 8 and 9 it will be appreciated that only one type of economizer outlet header, 12 or 12', would typically be employed for an economizer in a given steam generator. Similarly, while the earlier Figs. have employed the reference numeral 12 for the outlet header, it will be appreciated that either type of header 12 or 12' may be employed in all of these embodiments.

[0041] As discussed earlier, the present invention is particularly suited to maintaining a desired flue gas temperature entering a downstream SCR device. However, it will be appreciated that the invention may be used to maintain a desired gas temperature which may be required by other types of downstream devices, and for other purposes. One type of downstream device could be an air heater which typically uses the heat in the flue gas leaving the steam generator to heat the incoming air for combustion. In some cases it is desirable to control the flue gas temperature entering the air heater within a desired range or at a desired temperature above the acid dew point temperature, such as during low load operation, to reduce the possibility of condensation occurring which could form acidic compounds which could lead to corrosion of the air heater. Other types of downstream devices include various types of pollution control equipment; e.g., particulate removal devices such as electrostatic precipitators or fabric filters, and flue gas desulfurization devices such as wet or dry flue gas desulfurization equipment.

[0042] In the case of the present invention, and as particularly applied to apparatus and methods for controlling the temperature of flue gas temperature exiting from an

economizer, it will be appreciated that economizer gas outlet and/or gas inlet temperatures may be used to control the water flow rate through portions of the heat exchanger for the purpose of affecting the temperature of the flue gas after it has passed across the heat exchanger or economizer. However, due to the low flow rates which may be required for obtaining the desired outlet flue gas temperature, such a flue gas temperature control system may not provide a very quick response with respect to the boiler's capabilities for load control and operation, particularly when there is a large difference between the feedwater rates for the different passes through the economizer or heat exchanger.

[0043] Accordingly, another aspect of the present invention involves a control system and operation method which can accommodate such operating conditions. The system and method is not only applicable to the present invention but also to other heat exchanger systems that control the flow through different portions of a heat exchanger to achieve a desired flue gas temperature exiting from the heat exchanger.

[0044] FIGS. 10 and 11 illustrate the application of this concept to two different water proportioning or biasing systems. As illustrated in FIGS. 10 and 11, the present invention uses the feedwater flow rate entering the economizer to engage/disengage the economizer water internal proportion or bias system. Once engaged, the measured feedwater flow to the economizer is used to generate a proportioned or biased flow rate demand signal. The demand signal is then compared to the measured underflow proportioned or biased flow rate. If there is a difference between the demand signal flow rate and the measured flow rate, the control valve(s) modulating the proportioned or biased flow is/are adjusted.

[0045] More particularly, referring to FIG. 10, there is shown the application of the principles of the present invention to an embodiment of the present invention. In this case, feedwater is provided via main feedwater line 16 to the individual tubular configuration flow paths 1, 2 making up the economizer 3 via feedwater lines 15. A flow element FE 50 provided in line 16 produces a measured feedwater flow signal which is conveyed to a high/low limiter unit 52 and to a demand signal generator unit 54. The demand signal generator unit 54 produces a proportioned or biased flow rate demand signal, here an underflow rate demand signal, which is based upon the measured feedwater flow entering the economizer 3. This underflow rate demand signal is then conveyed to flow controller with bias unit 56. Flow controller with bias unit 56 also receives an actual measured underflow rate from flow element FE 58, indicative of the flow rate through the tubular configuration 1. Flow controller with bias unit 56 compares the underflow rate demand signal from unit 54 with the actual measured underflow rate from flow element FE 58, and produces a control valve signal which is conveyed to control valve 5 to modulate the feedwater flow through tubular configuration 1. The control valve signal from unit 56 is also conveyed to a signal inverter unit 60, and an inverted control valve signal is conveyed to the other control valve 5 to modulate the feedwater flow through tubular configuration 2. Since the unit 56 is a flow controller with bias capability, changes can easily be made to adjust the underflow rate demand signal in order to accommodate actual field performance; i.e., to adjust the flow splits between tubular configurations 1 and 2,

in order to achieve a desired flue gas temperature exiting the economizer and entering the downstream device, such as an SCR.

[0046] The demand signal generator unit 54 may generate the underflow rate demand signal in any manner known to those skilled in the art; lookup tables, calculations according to a predetermined equation(s) of underflow rate demand as a function of boiler load, etc. The demand signal generator unit 54 may also include a plurality of such tables or equations corresponding to different fuel types to be burned in the boiler.

[0047] The high/low limiter unit 52 receives the measured feedwater flow signal from flow element FE 50 and produces a high/low limit signal which is provided to block valve 62, located in the feedwater line 15 flow path supplying feedwater to tubular configuration 1. The high/low limiter is designed to position the block valve 62 at a specific open position, depending upon the boiler load as indicated by the boiler measured feedwater flow signal. For example, assume a boiler with a nominal megawatt (MW) capacity of 600 MW. The boiler operation may be considered to fall into one of three operating ranges: 0-200 MW, 200-400 MW, and 400-600 MW, and these ranges will determine the manner of operation of the control system of the multiple pass economizer according to the present invention.

[0048] In the 0-200 MW operating range, both the block valve 62 and the control valve 5 in the flow path supplying the tubular configuration 1 would normally be open. In the 200-400 MW operating range, the flue gas temperatures leaving the economizer 3 have increased over those experienced in the 0-200 MW range, but are typically not yet high enough to permit proper SCR operation. Thus, the principles of the present invention are employed; the block valve 62 would be closed to a specific setting in this case to provide additional flow resistance to tubular configuration 1, thereby allowing the control valves 5 to operate with more flexibility to modulate the feedwater flow through both tubular configurations 1, 2, and the flue gas temperature leaving the economizer 3 increases to a desired value. As boiler megawatt load continues to increase, into the 400-600 MW operating range, the feedwater modulating principles of the present invention can be gradually "phased out" and the control valves 5 can be opened wide and the block valve 62 can be opened in such a manner to obtain balance flow conditions in both tubular configurations 1, 2, since the flue gas temperature exiting from the economizer 3 is above the desired minimum value. While three, equally sized operating "ranges" have been described, unequal operating ranges may be employed. The general idea is that there are typically lower boiler operating ranges where the principles of the invention are generally not applied, an intermediate operating range where the invention is primarily used, and an upper boiler operating range where the principles of the present invention are not required and thus modulation of the control valves is gradually phased out because the flue gas temperatures are above the desired minimum levels.

[0049] Turning now to FIG. 11, there is shown the application of the principles of the present invention to another embodiment which is quite similar to the one disclosed in FIG. 10. In this case, one fundamental difference is that instead of two control valves 5 in each of the feedwater flow paths 15 supplying feedwater to tubular configurations 1, 2, there is only a single control valve 5 present and which is modulated to control feedwater flow through a single tubular

configuration; in this case, tubular configuration 2 (but which alternatively could have been tubular configuration 1, if desired). Another difference involves that fact that the single control valve 5 and the block valve 62 are located in parallel flow paths, rather than being in series with one another as in FIG. 10. Also, the block valve 62 in FIG. 11 could be operated in various conditions, fully open, partially open or fully closed, since the control valve 5 provides a flow path around block valve 62. Otherwise, the principles of operation are the same as in FIG. 10. Measured feedwater flow to the economizer 3 is used to generate a proportioned or biased flow rate demand signal at unit 54. The demand signal is then conveyed to the flow controller with bias unit 56 where it is compared to the measured underflow proportioned or biased flow rate from flow element FE 58. If there is a difference between the demand signal flow rate and the measured flow rate, the control valve 5 modulating the proportioned or biased flow is adjusted. Bias is applied as required to tune the performance of the system.

[0050] While the control system described above and with particular reference to FIGS. 10 and 11 can be used without reference to any measured flue gas temperatures, it is envisioned that a combination of the two approaches can be employed. That is, the measured feedwater flow to the economizer 3 can be used to generate a proportioned or biased flow rate demand signal at unit 54, and establish an initial flow rate. Then, a temperature measurement, such as the flue gas leaving the economizer, can then be used as a check or as a trim value to "fine tune" the positions of the control valve(s) 5.

[0051] It will thus be appreciated that the control system and operation method is particularly suited to operating conditions, such as low boiler load conditions, where the major portion of the water flow to the economizer must be proportioned or biased to meet the desired or target flue gas outlet temperature. The normal method of using outlet gas temperature to control water flow is not effective when a major amount of the water is proportioned or biased because the residence time of the water flowing through the (underflow section of the) economizer heating surface can no longer be measured in seconds or several minutes but stretches to almost an hour. This lengthy residence time in turn lengthens the time it takes to effectively make a change in gas temperature to the point that gas temperature can no longer be used to control the proportioned or biased water flow rate.

[0052] The advantage of the invention is that it allows systems which proportion or biased water flow rate in the economizer sections for the purpose of raising exiting gas temperature to be effective at lower boiler loads than can be achieved by a system which uses outlet gas temperature to control the feedwater proportioning or biased water flow rate. This allows an SCR located downstream of the boiler, if the boiler is so equipped, to continue to operate at lower boiler loads than previously possible using this type of system.

[0053] While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles. For example, the present invention may be applied to new boiler or steam generator construction involving selective catalytic reactors or other types of downstream devices, or to the replacement, repair

or modification of existing boilers or steam generators where selective catalytic reactors or other types of downstream devices and related equipment are or have been installed as a retrofit. In some embodiments of the invention, certain features of the invention may sometimes be used to advantage without a corresponding use of the other features. Accordingly, all such changes and embodiments properly fall within the scope of the following claims.

What is claimed is:

1. A system for maintaining a flue or combustion gas stream being directed into a downstream device within a desired temperature range or at a desired temperature, comprising:

an economizer located upstream of and in fluid communication with the downstream device, wherein the economizer comprises at least two tubular configurations disposed in a cross and or counter-current heat exchange relationship with the flow path of the gas stream generated by a boiler and having a flue inlet and a flue outlet,

the boiler being located upstream of and in fluid communication with the economizer,

each tubular configuration comprises a feedwater inlet and a feedwater outlet, the outlet of both tubular configurations being attached to an outlet header and the inlet of each tubular configuration being attached to a separate inlet header, and

a control system configured to independently control the flow of feedwater through each tubular configuration while maintaining a substantially constant total flow of feedwater through the economizer, and

the flow of feedwater through each tubular configuration is adjusted in a manner that transfers an appropriate amount of heat from the gas stream to maintain the gas stream within the desired temperature range or at the desired temperature.

2. The system of claim 1, wherein each tubular configuration comprises a plurality of serpentine tubes arranged horizontally or vertically back and forth within the economizer.

3. The system of claim 2, wherein the back and forth arrangement of the tubes is offset in a longitudinal, vertical, diagonal, or horizontal axis or direction of the economizer, or the arrangement is offset in a combination of such orientations.

4. The system of claim 1, wherein the amount of heat transferred from the gas stream is decreased by increasing the flow of feedwater through at least one of the tubular configurations and by reducing the flow of feedwater through the remaining tubular configurations, wherein the total flow of feedwater through the economizer is maintained substantially constant.

5. The system of claim 1, wherein the flow path of the gas stream is cross and or co-current with the flow of the feedwater.

6. The system of claim 2, wherein the back and forth arrangement of the tubes extends or expands in a longitudinal axis or direction of the economizer.

7. The system of claim 1, further comprising:

a first temperature sensor mounted about the gas inlet and or outlet of the economizer for measuring the inlet and outlet gas temperature;

a flow meter for measuring the flow of feedwater through the tubular configurations;

a second temperature sensor for measuring the feedwater temperature at the inlet and outlet of the tubular configurations; and

a plurality of control valves for adjusting the flow of the feedwater through the tubular configurations, wherein the first and second temperature sensor, the flow meter, and the control valves are in signal communication with the control system.

8. The system of claim 7, wherein the first and second temperature sensor, and flow meter are positioned and calibrated to provide the control system with the appropriate measurements for adjusting the heat transfer rate of the economizer.

9. The system of claim 8, wherein the heat transfer rate of the economizer is adjusted by a method, comprising the steps of:

selecting the appropriate tubular configuration; and

controlling the flow rate of the feedwater flowing through the selected tubular configuration.

10. The system of claim 9, wherein control system is configured to maintain the desired optimal temperature irrespective of the changes in the boiler load or in the temperature of the gas stream.

11. The system of claim 10, wherein maintaining the desired optimal temperature does not require bypassing the gas stream generated by the boiler.

12. The system of claim 2, wherein the tubular configurations are positioned adjacent to one other in a side-by-side non-overlapping relationship.

13. The system of claim 1, wherein each tubular configuration is provided with a different heat transfer capacity.

14. The system of claim 1, wherein the tubular configurations have different heat transfer characteristics from each other.

15. The system of claim 1, wherein the outlet header is provided with baffle means for encouraging mixing of feedwater from the tubular configurations prior to the feedwater exiting from the outlet header.

16. The system of claim 1, wherein at least one of the tubular configurations is provided with orifice means at one or both of the inlet and outlet of individual tubes to provide additional pressure drop to equalize flow distribution between each of the tubes in that tubular configuration.

17. The system of claim 1, wherein the downstream device comprises at least one of an SCR assembly, an air heater, particulate removal devices, and flue gas desulfurization devices.

18. A method of maintaining a gas stream being directed into a downstream device within a desired temperature range or at a desired temperature, the downstream device being located downstream of and in fluid communication with an economizer, the method comprising:

disposing, within the economizer, at least two tubular configurations in a cross and or counter-current heat exchange relationship with the flow path of the gas stream,

the economizer having a flue inlet and a flue outlet,

each tubular configuration comprises a feed water inlet and a feed water outlet, the outlet of both tubular configurations being attached to an outlet header and the inlet of each tubular configuration being attached to a separate inlet header,

monitoring the gas temperature at the flue inlet or flue outlet, the feedwater temperature at the feedwater inlet and outlet, and the flow of feedwater through the economizer; and

controlling the flow of feedwater conveyed through each tubular configuration, based on the measured temperatures and flow, to provide the tubular configurations with a combined heat transfer capacity that is effective to maintain the gas temperature within the desired temperature range or at the desired temperature, wherein the heat transfer capacity of the tubular configurations is decreased by increasing the flow of feedwater through at least one of the tubular configurations and by reducing the flow of feedwater through the other tubular configurations.

19. The method of claim 18, wherein each tubular configuration comprises a plurality of serpentine tubes arranged horizontally or vertically back and forth within the economizer.

20. The method of claim 19, wherein the back and forth arrangement of the tubes is offset in a longitudinal, vertical, diagonal, or horizontal axis or direction of the economizer, or the arrangement is offset in a combination of such orientations.

21. The method of claim 18, wherein the flow path of the gas stream is cross and or co-current with the flow of the feedwater.

22. The method of claim 19, wherein the back and forth arrangement of the tubes extends or expands in a longitudinal axis or direction of the economizer.

23. The method of claim 19, wherein the tubular configurations are positioned adjacent to one other in a side-by-side non-overlapping relationship.

24. The method of claim 18, wherein each tubular configuration is provided with a different heat transfer capacity.

25. The method of claim 18, wherein the tubular configurations have different heat transfer characteristics from each other.

26. The method of claim 18, comprising directing the flue gas stream into a downstream device which includes at least one of an SCR assembly, an air heater, particulate removal devices, and flue gas desulfurization devices.

27. A system for maintaining a flue or combustion gas stream being directed into a downstream device within a desired temperature range or at a desired temperature, comprising:

an economizer located upstream of and in fluid communication with the downstream device, wherein

the economizer comprises at least two tubular configurations disposed in a cross and or counter-current heat exchange relationship with the flow path of the gas stream generated by a boiler and having a flue inlet and a flue outlet,

the boiler being located upstream of and in fluid communication with the economizer,

each tubular configuration comprises a feedwater inlet and a feedwater outlet, the outlet of both tubular configurations being attached to an outlet header and the inlet of each tubular configuration being attached to a separate inlet header, and a control system configured to independently control the flow of feedwater

through each tubular configuration while maintaining a substantially constant total flow of feedwater through the economizer, and

the flow of feedwater through each tubular configuration is adjusted in a manner that transfers an appropriate amount of heat from the gas stream to maintain the gas stream within the desired temperature range or at the desired temperature based upon a proportioned or biased flow rate demand signal generated as a function of measured feedwater flow to the economizer.

28. The system of claim **27**, comprising means for comparing a measured flow rate in at least one of the tubular configurations to the proportioned or biased flow rate demand signal, means for determining if there is a difference between the demand signal flow rate and the measured flow rate, and control valve means responsive to said difference for modulating the flow of feedwater through at least one of the tubular configurations.

29. The system of claim **28**, comprising demand signal generator means for generating the proportioned or biased flow rate demand signal as a function of measured feedwater flow to the economizer and fuel type to be burned in the boiler.

30. The system of claim **27**, wherein the control system determines whether to control the flow of feedwater through each tubular configuration while maintaining a substantially constant total flow of feedwater through the economizer to transfer an appropriate amount of heat from the gas stream to maintain the gas stream within the desired temperature range or at the desired temperature based upon whether the boiler is in a lower, intermediate or upper operating range.

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(19) **United States**(12) **Patent Application Publication****Cerney et al.**(10) **Pub. No.: US 2010/0229805 A1**(43) **Pub. Date: Sep. 16, 2010**(54) **INTEGRATED SPLIT STREAM WATER COIL
AIR HEATER AND ECONOMIZER (IWE)****Publication Classification**(51) **Int. Cl.****F22D 7/00** (2006.01)**F22B 29/12** (2006.01)(52) **U.S. Cl.** **122/406.4**(57) **ABSTRACT**

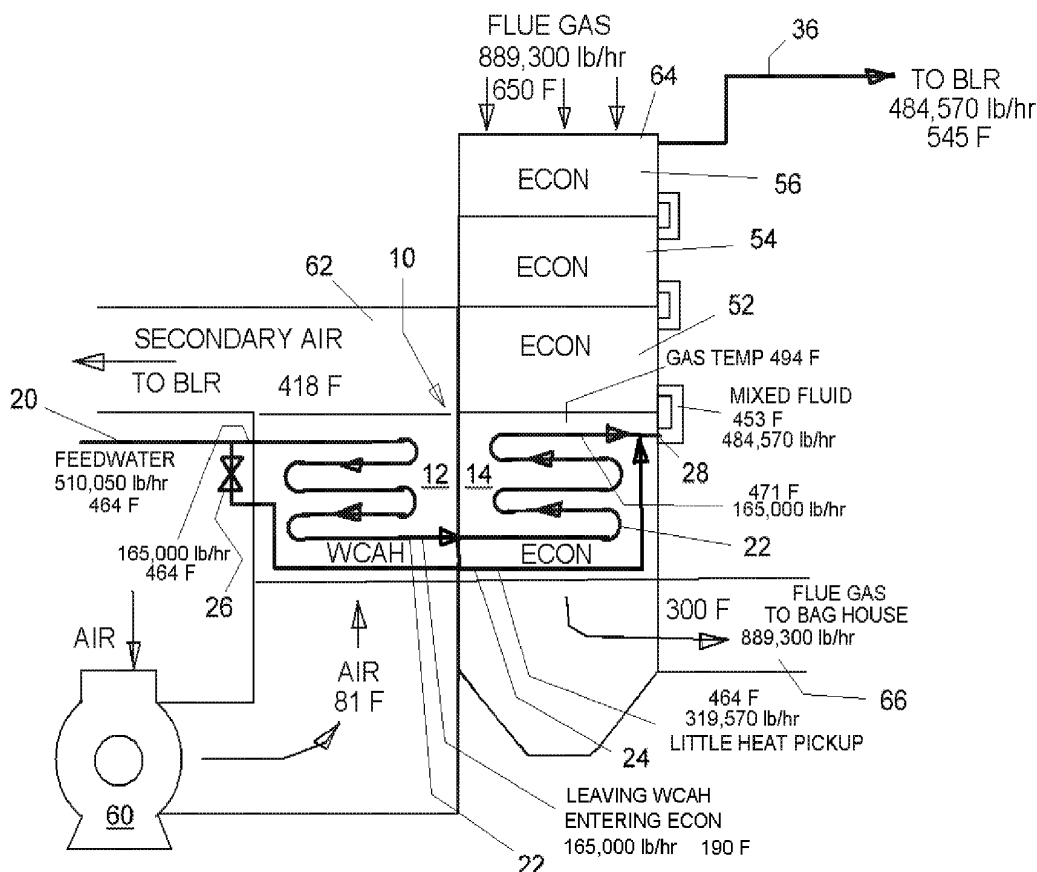
An integrated water coil air heater and economizer arrangement for a boiler has a feedwater inlet for supplying feedwater to the boiler, and conduits and a valve for splitting the feedwater from the inlet into a first partial lower temperature, lower mass flow stream, and a second partial higher temperature, higher flow stream. A water coil air heater for passage of air to be heated for the boiler contains at least one heat transfer loop in heat transfer relationship with the air, the heat transfer loop of the water coil air heater being connected to receive the first partial stream. An economizer for passage of flue gas to be cooled for the boiler contains at least one heat transfer loop in heat transfer relationship with the flue gas, the heat transfer loop of the economizer being connected to the heat transfer loop of the water coil air heater for receiving the first partial stream from the water coil air heater. A mixing location downstream of the economizer receives and reunites the first and second partial streams and a conduit carries the second partial stream from the feedwater inlet to the to the mixing location.

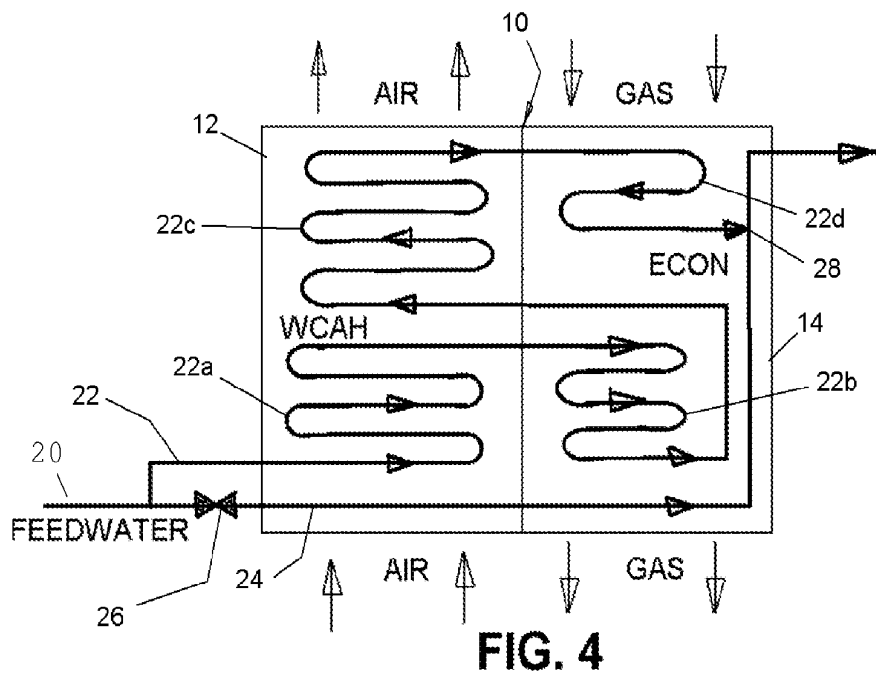
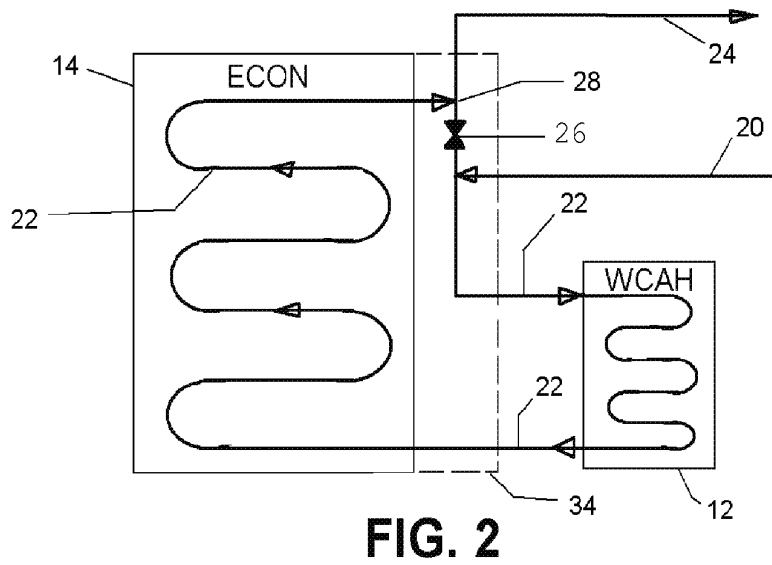
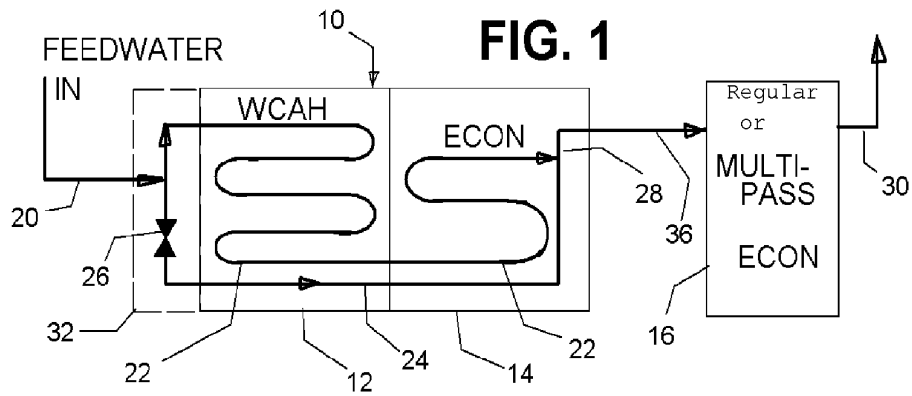
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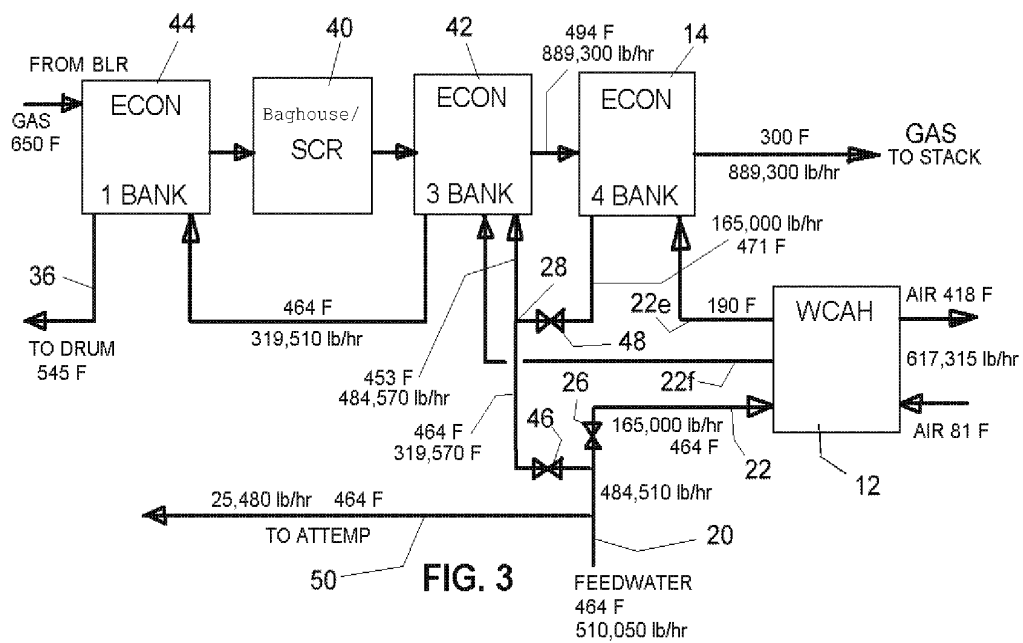
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BARBERTON, OH 44203 (US)**(21) **Appl. No.: 12/581,637**(22) **Filed: Oct. 19, 2009****Related U.S. Application Data**

(60) Provisional application No. 61/158,774, filed on Mar. 10, 2009.







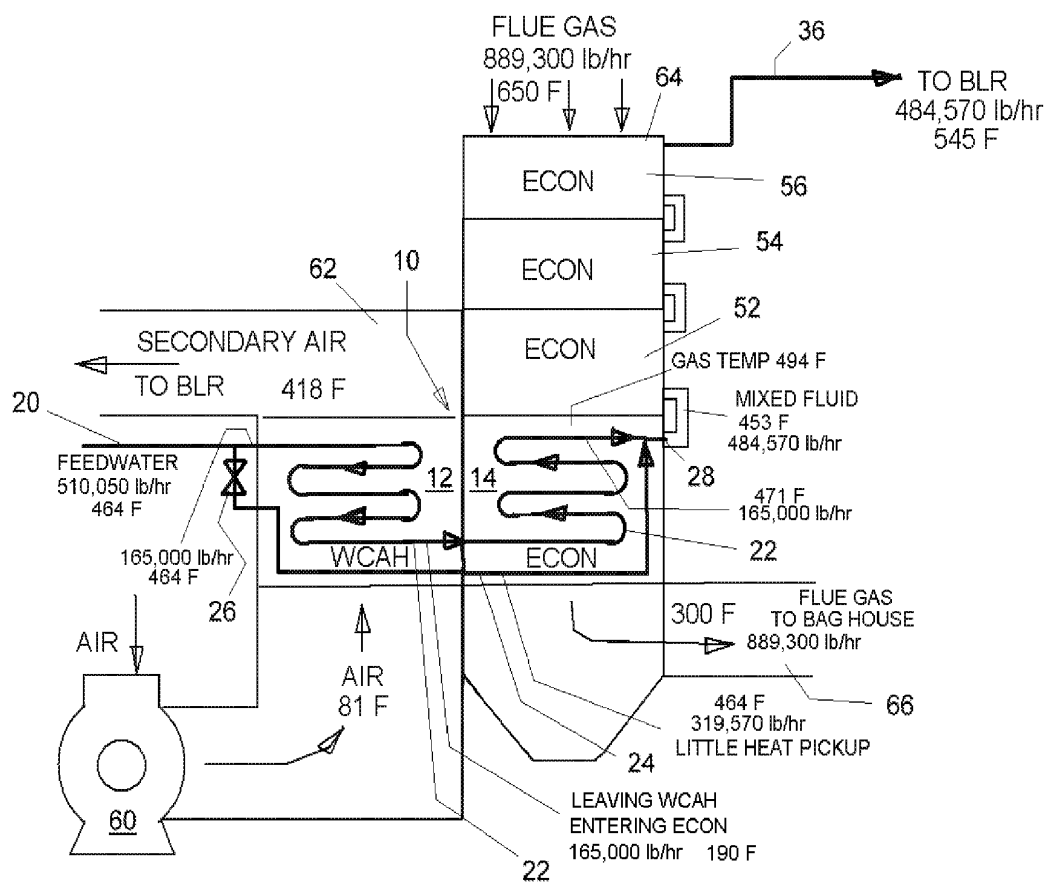


FIG. 5

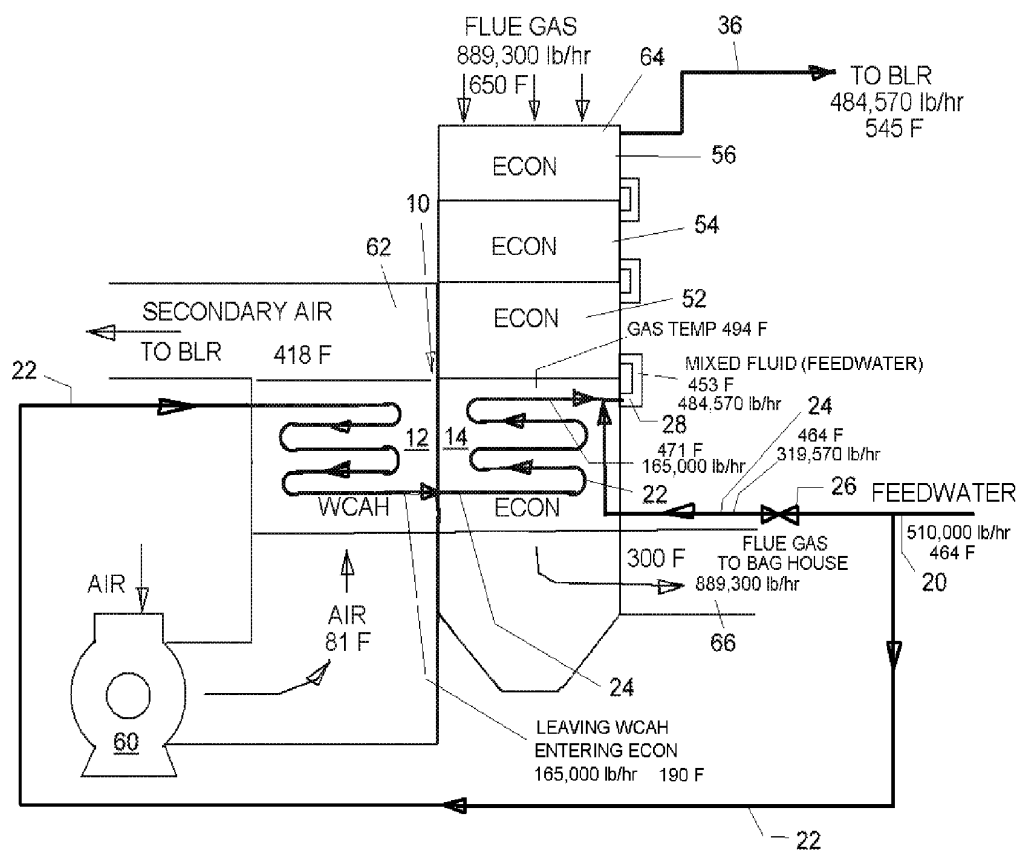


FIG. 6

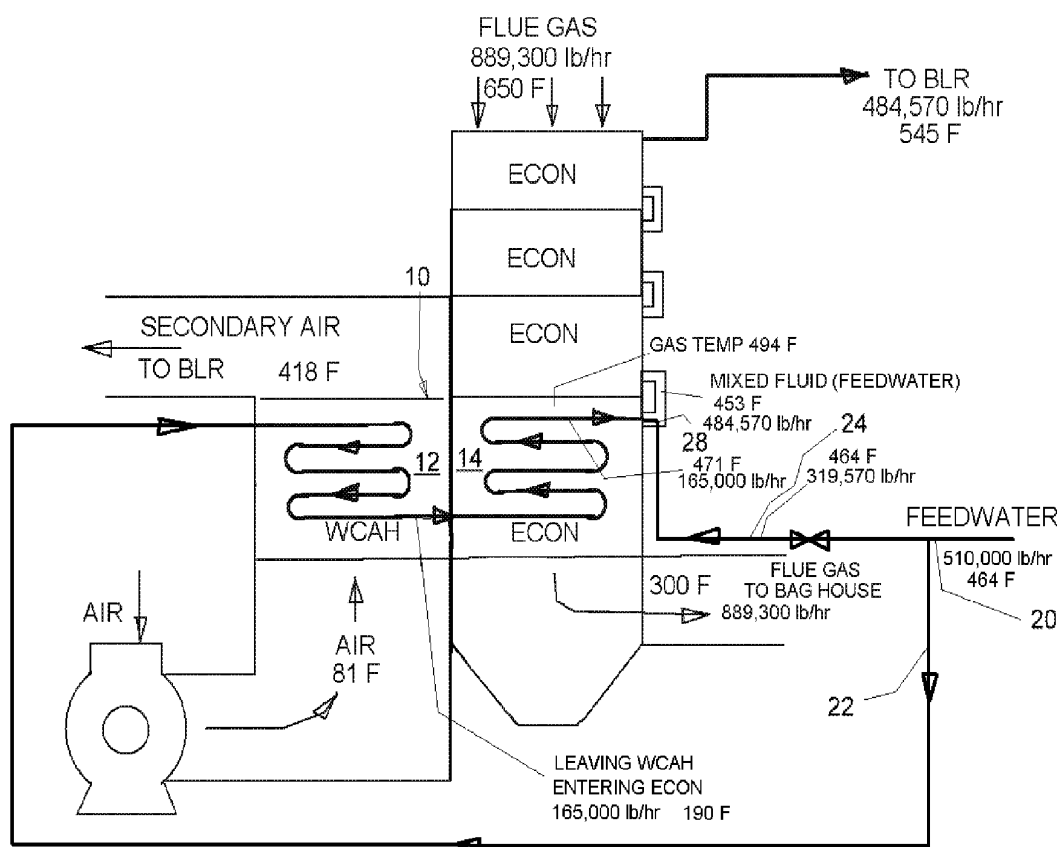


FIG. 7

INTEGRATED SPLIT STREAM WATER COIL AIR HEATER AND ECONOMIZER (IWE)

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 61/158,774, titled "IWE", filed Mar. 10, 2009, the disclosure of which is hereby incorporated by reference as though fully set forth herein.

FIELD AND BACKGROUND OF THE INVENTION

[0002] The present invention relates generally to the field of boilers and steam generators and, in particular, to air heaters for heating combustion air.

[0003] The tubular air heater is the main air heating mechanism with the water coil air-heater (WCAH) as a commonly used alternative. A tubular air heater or WCAH is currently used to heat combustion air to a specified operating temperature. The full flow of the boiler's feedwater is used as the heat transfer medium when using the WCAH as the heat source. As the air is heated, the temperature of the feedwater is lowered. The feedwater leaving the WCAH is then sent to an economizer where it is used to lower the temperature of the flue gas of the boiler. In certain cases a tubular air-heater (TAH) in conjunction with a WCAH is used to obtain a lower final exit gas temperature. As the stack gas temperature decreases the size of the TAH and WCAH increases. The size of the air-heaters will increase substantially as the gas temperature drops below 325 degrees F. The current technology is limited by the feedwater temperature, the stack gas temperature, and the required combustion air temperature.

[0004] U.S. Pat. No. 3,818,872 to Clayton, Jr. et al. discloses an arrangement for protecting, at low loads, furnace walls of a once-through steam generator having a recirculation loop, by bypassing some of the incoming feedwater flow around the economizer of the arrangement.

[0005] U.S. Pat. No. 4,160,009 to Hamabe discloses a boiler apparatus containing a denitrator which utilizes a catalyst and which is disposed in an optimum reaction temperature region for a catalyst of the denitrator. In order to control the temperature of the combustion gas in the optimum reaction temperature region, this region is adapted to communicate with a high temperature gas source or a low temperature gas source through a control valve.

[0006] U.S. Pat. No. 5,555,849 to Wiechard et al. discloses a gas temperature control system for the catalytic reduction of nitrogen oxide emissions where, in order to maintain a flue gas temperature up to the temperature required for the NOx catalytic reactor during low load operations, some feedwater flow bypasses the economizer of the system by supplying this partial flow to a bypass line to maintain a desired flue gas temperature to the catalytic reactor.

[0007] Published Patent Applications US 2007/0261646 and US 2007/0261647 to Albrecht et al., the disclosures of which are hereby incorporated by reference as though fully set forth herein, disclose a multiple pass economizer and method for SCR temperature control where maintaining a desired economizer outlet gas temperature across a range of boiler loads comprises a plurality of tubular configurations having surfaces that are in contact with the flue gas. Each tubular configuration may comprise a plurality of serpentine or stringer tubes arranged horizontally or vertically back and

forth within the economizer, and each tubular configuration has a separate feedwater inlet.

[0008] Current technologies typically supply flue gas at or near the stack of the boiler system at well above 300 degrees F. It would be advantageous if a system were discovered that could economically lower this flue gas exit temperature.

SUMMARY OF THE INVENTION

[0009] It is an object of the present invention to obtain a lower final exit gas temperature for a boiler than what is economically possible with current technologies. The invention increases the driving force between the feedwater and the flue gas. This increased driving force improves heat transfer between the water and the flue gas, resulting in a much smaller heat transfer area than is needed when using traditional means.

[0010] To increase the driving force within the economizer the Log Mean Temperature Difference (LMTD) between the water and the flue gas is increased above what is possible with current technologies. Using current technology, under certain conditions the LMTD cannot be increased enough to allow for heat transfer to occur. The present invention solves that problem by increasing the LMTD of only a portion of the water flow going through the economizer while minimizing heat transfer occurring to the remaining water flow passing through the economizer.

[0011] According to the invention, an integrated water coil air heater (WCAH) and economizer (together hereinafter referred to or called an IWE) provides multiple water flow paths within the WCAH and economizer. The full flow of the feedwater enters the IWE as a single stream or multiple streams. Either outside the WCAH or once within the WCAH section of the IWE, the feedwater flow is split into two or more streams (split stream WCAH). The flow is biased between the split streams based on desired operating conditions.

[0012] The various novel features which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific benefits attained by its uses, reference is made to the accompanying drawings and descriptive matter which illustrate preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] In the drawings:

[0014] FIG. 1 is a schematic diagram of one embodiment of the IWE of the present invention;

[0015] FIG. 2 is a schematic diagram of another embodiment of the IWE of the present invention;

[0016] FIG. 3 is a block diagram of a still further embodiment of the IWE of the present invention which has multiple separate economizer banks;

[0017] FIG. 4 is a schematic diagram of a still further embodiment of the IWE of the present invention;

[0018] FIG. 5 is a schematic diagram of a furnace section of a boiler containing the IWE of the present invention according to FIG. 1;

[0019] FIG. 6 is a schematic diagram of a furnace section of a boiler similar to FIG. 5 but containing the IWE of a further embodiment of the present invention; and

[0020] FIG. 7 is a schematic diagram of a furnace section of a boiler similar to FIG. 5 but containing the IWE of a still further embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Referring now to the drawings, wherein like reference numerals are used to refer to the same or functionally similar elements throughout the several drawings, FIG. 1 shows an integrated water coil air heater or WCAH 12 and economizer or ECON 14 that together form the IWE 10 of the invention. The IWE can also be used with a multi-pass economizer 16 of the type disclosed in Published Patent Applications US 2007/0261646 and US 2007/0261647, which may receive the output water from economizer 14 of the IWE 10.

Description of the Apparatus

[0022] The total input of feedwater at inlet 20, is divided by split means such as conduits and one or more valves, into a first partial high temperature, lower mass flow stream 22, and a second partial higher temperature, higher mass flow stream 24. The first partial stream 22 passed through at least one heat transfer loop in the WCAH 12 that contains a major portion of the heat transfer surface of the WCAH 12, and is used to increase the LMTD between the water and the economizer gas. This is done by using only a portion of the total water flow to heat the air passing the WCAH 12. This results in a much lower water temperature entering the economizer 14. The second partial stream 24 travels along a conduit and has minimal heat transfer surface and is used to move the majority of the water. Both streams 22 and 24 pass through the economizer 14 for simplicity of construction, so that both streams have some heat transfer effect to allow for biasing of the flow and thus better control, and to minimize thermal shock when the streams are reunited. The amount of flow in each stream is determined by the set point of a valve 26.

[0023] The water in each stream remains split throughout the WCAH section 12 and the streams enter the economizer section 14 as two separate streams (split stream). The water enters the economizer section of the IWE 10 as a lower temperature, lower mass flow stream 22, and a higher temperature, high flow stream 24. The streams remain split throughout the economizer section 14 (split stream economizer). The low temperature low flow stream 22 is used as the major heat transfer medium with the flue gas. This stream 22 travels through the majority of the heat transfer surface in both the WCAH 12 and ECON 14. The high temperature, high flow stream 24 has minimal heat transfer surface to reduce heat transfer with the flue gas.

[0024] Once both streams 22 and 24 have passed completely or mostly through the economizer section 14, they are combined in the mixing section 28 of the IWE 10, that is either inside, or outside, but is at least near the downstream end of the economizer 14. This combined stream then exits the IWE and is either sent at 30 through the steam drum of the boiler (not shown) or from the output 36 of economizer 14, through a non-split stream economizer or multi-pass economizer 16, for further heat transfer work.

[0025] As shown by the dotted line 32 enclosing the upstream ends of streams 22 and 24 and the valve 26, the split in the feedwater may occur within the water coil air heater enclosure or WCAH 12.

[0026] Another embodiment of the IWE is illustrated in FIG. 2 where the split in streams 22 and 24, the valve 26 and the mixing section 28, may all be upstream of the WCAH 12 or, as shown by dotted line 34, both upstream of the WCAH 12 and inside the economizer 14.

[0027] FIG. 4 illustrates a still further embodiment of the IWE where the lower temperature, lower mass flow stream 22 first passed a heat exchange loop 22a in WCAH 12 that is being supplied by an upward flow of combustion air and therefore cooled. The stream 22 then enters a second heat exchange loop 22b in the economizer 14 to be heated by flue gas passing downwardly in the economizer, then to a third heat transfer loop 22c back in WCAH 12 for giving up heat to the air and coming to about the air temperature, and then once again to a fourth loop 22d for again being heated by the flue gas before reuniting with the higher temperature, higher flow stream 24 at mixing section 28.

[0028] The upstream split in feedwater 20 into streams 22 and 24 and valve 26 are shown outside WCAH 12 in FIG. 4 but they may alternatively be inside the WCAH 12.

[0029] FIG. 3 is a block diagram of another embodiment of the invention that includes exemplary flow rates and temperatures as well as illustrates how a Selective Catalytic Reduction unit of Nitrogen Oxides or SCR 40 can be incorporated into the invention. The economizer 14 of the IWE of the invention, which may be a 4 bank economizer, is downstream of the SCR 40 and receives the lower temperature, lower mass flow stream 22e from WCAH 12. Alternatively, part or all of the lower temperature, lower mass flow stream 22f from WCAH 12 is supplied to a second 3 bank economizer 42, which also receives all of the high temperature, high flow rate feedwater stream 24 after it has been reunited with the stream 22e leaving economizer 14 at mixing section 28. Valves 26, 46 and 48 are set to control the streams 22 and 24 and their distribution amount to the economizers 14 and 42. Some feedwater may also be tapped at 50 to be supplied to an attemperator (not shown). The recombined feedwater flow from economizer 42 is then supplied to a 1 bank economizer 44 that is upstream of the SCR, before going to the steam drum at 36.

[0030] FIG. 3 also illustrates the counter current flue gas flow first into economizer 44 at 650 F, then through the SCR 40 and on to the economizer 42 and, at a flow of 889,300 lb/hr and 494 F, to economizer 14 of the IWE, and finally, at an acceptable stack gas temperature of 300 F, the full flue gas flow is discharged. Combustion air at 617,315 lb/hr and 81 F enters the WCAH 12, is heated, and then leaves at a temperature of 418 F. As noted above, temperatures and flow rates for the feedwater streams are shown in FIG. 3.

[0031] FIGS. 5, 6 and 7 illustrate embodiments of the IWE of the present invention in boiler furnace sections and also show exemplary conditions for operation of the invention.

[0032] In FIG. 5, the IWE 10 with WCAH 12 and ECON 14 receive the feedwater streams 22 and 24, split by valve 26 from the feedwater inlet 20, and the feedwater streams are reunited and mixed at 28 before being supplied to a second economizer 52 where additional heat from flue gas inlet 64 at the top of the furnace section at 650 F, is taken up by the water. The combined feedwater flow is then supplied in series to a third economizer 54 and then a fourth economizer 56, before being discharged at 36 and at 545 F to return to other sections of the boiler.

[0033] Flue gas, now cooled to 300 F, is supplied at outlet 66 to the furnace stack (not shown).

[0034] Meanwhile combustion air is supplied by a blower 60 to the WCAH 12 at 81 F, where it is heated to 418 F before being supplied as secondary air at 62, by feedwater supplied at inlet 20, at 464 F.

[0035] A similar apparatus to that of FIG. 5 is shown in FIG. 6 where, however, the feedwater 20 is split so that one partial stream 22 goes through the WCAH 12 and the discharge from WCAH 12 is supplied to economizer 14 where it is reunited with the other partial feedwater stream 24 from valve 26, so that all the feedwater is heated by flue gas passing through the economizer 14.

[0036] In the embodiment of FIG. 7, which is similar to that of FIG. 6, except that only one stream 22 of feedwater passed in the economizer 14, while the other stream 24 that had been split from the total feedwater inlet 20, is reunited with stream 22 outside the economizer 14 at 28. In this way only a portion of the feedwater, i.e. stream 22, is cooled in the WCAH 12.

Further Description of the Process

Feedwater Flow Path:

- [0037] 1. Feedwater (20) enters boiler boundary at full flow and temperature.
- [0038] 2. The feedwater enters the IWE in the biasing section of the split stream WCAH (12) where it is split into two streams (22, 24). Both streams remain separate throughout the IWE (10).
- [0039] 3. The first stream (22) is passed through the majority of the WCAH's tubes (heating surface).
- [0040] 4. The second stream (24) is sent through a single stream with minimal heating surface.
- [0041] 5. The majority of the heat transfer occurs in the first stream which lowers the temperature of the water in that stream. Minimal heat transfer occurs in the second stream as it passes through the WCAH section.
- [0042] 6. Both streams exit the WCAH section and enter the split stream economizer section.
- [0043] 7. The first stream passes through the majority of the economizer tubes (heating surface). This stream does the majority of the cooling of the gases.
- [0044] 8. The second stream passes through a single large tube with minimal heat transfer surface.
- [0045] 9. After both streams pass through the economizer section of the IWE, they enter a mixing section (28).
- [0046] 10. Within the mixing section the two streams are mixed together and then exit the IWE (10).
- [0047] 11. After the water leaves the IWE it is sent to the drum or other economizer section(s) as a single flow stream.

Flue Gas Flow Path:

- [0048] 1. The flue gas exits the boiler and passes through other heat transfer surface.
- [0049] 2. The flue gas then enters into the economizer section of the IWE.

[0050] 3. The gas passes over both streams with the majority of the heat transfer occurring in the low temperature low flow heating surface.

[0051] 4. The flue gas then exits the IWE.

Control of Feedwater Split

[0052] The control methodology for setting of valve 26, and therefore the relative feedwater amounts in the first and second partial streams 22 and 24, is similar to that of Published Patent Applications US 2007/0261646 and US 2007/0261647. Under this methodology an algorithm is developed to quantify theoretical steady state conditions, wherein mass flow rates are utilized as inputs. The algorithm is necessary as steady state can take upwards of an hour or more to reach, thus making real time temperature measurements downstream of the economizer potentially misleading in the event steady state has not be reached. Once steady state is reached the algorithms can be "trimmed" (i.e. proportionally adjusted) to make up for actual vs. theoretical operational differences. The algorithm used is dependent upon the actual size of the equipment and mass flow rates available.

[0053] While specific embodiments of this invention have been shown and described in detail to illustrate the application and principles of the invention, it will be understood that it is not intended that the present invention be limited thereto and that the invention may be embodied otherwise without departing from such principles. For example, the present invention may be applied to new construction involving boilers or steam generators, or to the replacement, repair or modification of existing boilers or steam generators. In some embodiments of the invention, certain features of the invention may sometimes be used to advantage without a corresponding use of the other features. Accordingly, all such changes and embodiments properly fall within the scope of the following claims (including any and all equivalents).

What is claimed is:

1. An integrated water coil air heater and economizer arrangement for improving log mean temperature difference for a boiler, comprising:

a feedwater inlet for supplying feedwater to the boiler; split means for splitting the feedwater from the inlet into a first partial high temperature, lower mass flow stream, and a second partial higher temperature, higher flow stream;

a water coil air heater for passage of air to be heated for the boiler, the water coil air heater containing at least one heat transfer loop in heat transfer relationship with the air, the heat transfer loop of the water coil air heater being connected to the split means for receiving the first partial stream;

an economizer for passage of flue gas to be cooled for the boiler, the economizer containing at least one heat transfer loop in heat transfer relationship with the flue gas, the heat transfer loop of the economizer being connected to the heat transfer loop of the water coil air heater for receiving the first partial stream from the water coil air heater;

mixing means near a downstream end of the economizer for receiving and reuniting the first and second partial streams; and

a conduit connected between the split means and the mixing means for passing the second partial stream to the mixing means.

2. A method for improving log mean temperature difference for an economizer of a boiler, comprising:

supplying a feedwater stream to the boiler;
splitting the feedwater stream into a first partial high temperature, lower mass flow stream, and a second partial higher temperature, higher flow stream;
supplying the first partial stream to a water coil air heater for passage of air to be heated for the boiler, the water coil air heater containing at least one heat transfer loop in heat transfer relationship with the air, the first partial stream being passed through the heat transfer loop of the water coil air heater;
supplying the first partial stream after it has passed through the heat transfer loop of the water coil air heater, to an

economizer for passage of flue gas to be cooled for the boiler, the economizer containing at least one heat transfer loop in heat transfer relationship with the flue gas, the first partial stream from the water coil air heater being passed through the heat transfer loop of the economizer;
conducting the second partial stream to a downstream end of the economizer; and
reuniting the first and second partial streams near the downstream end of the economizer.

* * * * *