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Señor Director
DIRECCION DE NUEVAS CREACIONES
Superintendencia de Industria y Comercio
E. S. D.

Trámite : 002
Evento : 001
Actuación : 329

Referencia : Expediente No. 14.142.238
Asunto : Solicitud de patente para: **SISTEMA PARA PRODUCIR VAPOR DE ALTA PRESIÓN DE AGUA DE BAJA CALIDAD**
Solicitante : **BABCOCK & WILCOX POWER GENERATION GROUP, INC**
Clase : C02F 001/000
Fecha de solicitud : 2 de junio de 2014

1. Yo, Luz Clemencia de PAEZ, en mi condición de apoderada de la sociedad solicitante, **BABCOCK & WILCOX POWER GENERATION GROUP, INC**, atentamente presento los siguientes documentos:

Prioridades: Presento con este escrito copias certificadas de la solicitud de patente USA No. 61/842,157 y 14/298,381 presentadas en Estados Unidos de América el 02 de julio de 2013 y el 06 de junio de 2014, de las cuales se reclama prioridad en esta solicitud de patente, junto con la correspondiente traducción al español

Las copias certificadas del documento de prioridad están siendo presentadas dentro del término legal correspondiente, esto es 02 de noviembre de 2014, de conformidad con lo establecido en los artículos 10 y 11 de la Decisión 486 de la Comisión de la Comunidad Andina.

2. **Documento de cesión de derechos de los inventores:** Adicionalmente acompaño con este escrito un (1) documento en español-inglés en el que consta la cesión de derechos de los tres (3) inventores a favor de la sociedad solicitante **BABCOCK & WILCOX POWER GENERATION GROUP, INC**

"EXCELENCIA LEGAL EN UN MUNDO SIN FRONTERAS"

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Por lo anterior, comedidamente solicito se prosiga con el trámite de este asunto.

Señor Director,

Luiz Clemencia de Páez
LUZ CLEMENCIA DE PÁEZ
C.C. No. 35.456.344 de Usaquén
T.P.A. 23.555

COPIA
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LOS ESTADOS UNIDOS DE AMÉRICA
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10 de julio de 2014

POR MEDIO DE LA PRESENTE SE CERTIFICA QUE EL DOCUMENTO QUE FIGURA EN ANEXO ES UNA COPIA FIEL TOMADA DE LOS ARCHIVOS DE LA OFICINA DE MARCAS Y PATENTES DE LOS ESTADOS UNIDOS, DE AQUELLOS DOCUMENTOS DE LA SOLICITUD DE PATENTE IDENTIFICADA A CONTINUACIÓN QUE CUMPLIÓ CON LOS REQUISITOS PARA OTORGÁRSELE UNA FECHA DE PRESENTACIÓN BAJO 35 USC 111.

NÚMERO DE SOLICITUD: *14/298,381*

FECHA DE PRESENTACIÓN: *06 de junio de 2014*

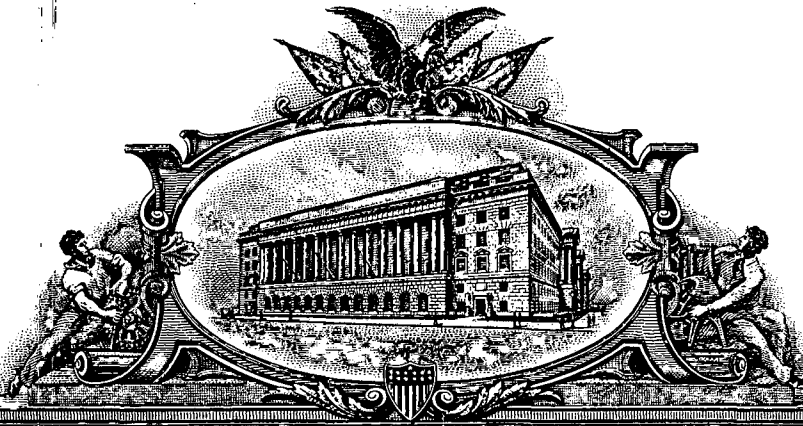
EL CÓDIGO DEL PAÍS Y EL NÚMERO DE SU SOLICITUD DE PRIORIDAD, A USARSE PARA LA PRESENTACIÓN EN EL EXTRANJERO BAJO LA CONVENCIÓN DE PARÍS, ES *US14/298,381*

Con autorización del
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[Firma ilegible]
T. WALLACE
Oficial de Registro

Sello: OFICINA DE MARCAS Y PATENTES DE LOS ESTADOS UNIDOS. DEPARTAMENTO
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APPLICATION NUMBER: 14/298,381

FILING DATE: June 06, 2014

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS US14/298,381

By Authority of the

**Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office**


T. WALLACE
Certifying Officer



Electronic Acknowledgement Receipt

EFS ID:	19237483
Application Number:	14298381
International Application Number:	
Confirmation Number:	1449
Title of Invention:	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER
First Named Inventor/Applicant Name:	Donald E RYAN
Customer Number:	41669
Filer:	Eric Marich/Amy Saus
Filer Authorized By:	Eric Marich
Attorney Docket Number:	Case 7564
Receipt Date:	06-JUN-2014
Filing Date:	
Time Stamp:	16:24:32
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Payment Type	Deposit Account
Payment was successfully received in RAM	\$ 1600
RAM confirmation Number	3029
Deposit Account	501813
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	Case_7564_ADS_aia0014.pdf	1571853	no	7
			8393dd822566cd0411db7f039070d0c156bb436c		
Warnings:					
Information:					
2		Case_7564_App.pdf	187148	yes	16
			d16a2f1bad0a45ef99193a37a3ea38c50883d802		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	12	
	Claims		13	15	
	Abstract		16	16	
Warnings:					
Information:					
3	Drawings-only black and white line drawings	Case_7564_Figs.pdf	42198	no	3
			0e19197ccd66e590cd3fd79d1338e759050630c3		
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	33120	no	2
			bb54e7e04e558a7ef3e0fac8df290cc604b88c9c		
Warnings:					
Information:					
Total Files Size (in bytes):			1834319		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Serial No. 61/842,157, filed July 2, 2013 entitled "System for Producing High Pressure Steam from Low Quality Water". U.S. Provisional Application Serial No. 61/842,157, filed April 11, 2013 entitled "Dual System for Producing High Pressure Steam from Low Quality Water" is incorporated by reference herein in its entirety.

BACKGROUND

[0002] The present disclosure relates to systems and methods for producing high pressure steam using a poor or low quality feedwater source. This can be accomplished without continuously treating large quantities of water.

[0003] During combustion, the chemical energy in a fuel is converted to thermal heat inside the furnace of a boiler. The thermal heat is captured through heat-absorbing surfaces in the boiler to produce steam. The fuels used in the furnace include a wide range of solid, liquid, and gaseous substances, including coal, natural gas, and diesel oil.

[0004] Steam generation from a boiler system involves thermal and physical processes of heat transfer, fluid flow, evaporation, and condensation of a feedwater fluid mixture that includes water and steam. As the temperatures and pressures of the feedwater and the produced steam change, dissolved materials in the water can precipitate and/or deposit in the waterside of the boiler. These include materials such as oxides, hydroxides, hydrates, carbonates, and other organic/chemical impurities. These deposits can result in the formation of scale on the insides of tube surfaces, or can facilitate corrosion of structural materials within the boiler system. These deposits and /or corrosion combined with the high heat fluxes found in the furnace section of a

boiler may lead to tube failures. While scale/deposits can be removed using various maintenance and clean-up processes, this leads to downtime.

[0005] Typical systems for supplying high-pressure high-temperature steam to various processes generally involve the direct heating of the feedwater in the boiler. High purity feedwater is typically required to avoid scale/deposits within the tubes of the boiler, other devices associated with the system, and the piping in fluid communication therewith. Low quality feedwater can be treated/cleaned to obtain high purity feedwater. While this is acceptable in a closed loop where the treated high purity feedwater is recycled through the boiler, the treatment/clean-up of the feedwater becomes prohibitively expensive in an open loop cycle because the feedwater treatment system would need to continuously produce high purity water at a rate that is equal to the steam flow requirement of the process. Otherwise, the heat flux in the boiler tubes caused by using low quality feedwater would result in deposits/accumulation of impurities.

[0006] However, not all commercial processes that require high-pressure steam also require the steam be at as high a level of purity as the feedwater for a boiler system. It would be desirable to provide systems and methods that can produce high-pressure steam without the concurrent need to continuously produce or use high quality feedwater, and without increasing boiler downtime or maintenance.

BRIEF DESCRIPTION

[0007] The present disclosure relates to a system for producing high pressure steam from low quality feedwater for a designated process. The system includes a first closed loop piping system in fluid communication with a boiler and a heat exchanger assembly. A first fluid is provided within the first closed loop piping system, and a portion of the first fluid exits the boiler as high-temperature steam having a boiler output temperature. A second loop piping system for the designated process is in fluid communication with the heat exchanger assembly, and contains the low quality feedwater. The heat from the first fluid is transferred to the low quality feedwater through the heat exchanger. The first piping system and second piping system are not in fluid communication, i.e. the first fluid and the low quality feedwater do not mix together.

[0008] Disclosed in some embodiments are systems for producing high-pressure steam from low quality feedwater, comprising: a first closed loop containing a first fluid, the first closed loop containing a boiler and a heat exchanger assembly downstream of the boiler, wherein at least a portion of the first fluid exits the boiler as a high-temperature steam having a boiler output temperature; and a second loop in fluid communication with the heat exchanger assembly, the second loop containing the low quality feedwater; wherein the heat exchanger assembly is adapted to receive the first fluid from the boiler and transfer heat from the first fluid to the low quality feedwater in the second loop so that the low quality feedwater exits the heat exchanger assembly as a high-pressure steam and the first fluid exits the heat exchanger assembly as a condensed steam having a heat exchanger discharge temperature.

[0009] The heat exchanger assembly may include a plurality of heat exchangers. Those heat exchangers can be arranged in series or parallel. In particular embodiments, at least two heat exchangers in the plurality of heat exchangers are arranged in parallel.

[0010] The low quality feedwater can exit the heat exchanger assembly as supercritical steam.

[0011] The first closed loop can further comprise a deaerator downstream of the heat exchanger assembly for treating the condensed steam prior to reintroducing the first fluid into the boiler. The system may include a bypass segment directly connecting the boiler and the deaerator. The first fluid in the bypass segment may be in the form of saturated steam. The first closed loop can also further comprise a make-up feedwater system for providing additional first fluid.

[0012] In particular embodiments, the boiler output temperature of the first fluid is at least 100°F greater than the temperature of the low-quality feedwater exiting the heat exchanger assembly.

[0013] Also disclosed herein are methods for producing high-pressure steam from low quality feedwater, comprising: heating a first fluid in a boiler, wherein at least a portion of the first fluid exits the boiler as a high-temperature steam having a boiler output temperature; sending the high-temperature steam to a heat exchanger assembly, the boiler and the heat exchanger assembly forming a first closed loop; and sending the

low quality feedwater to the heat exchanger assembly, the low quality feedwater being in a second loop separate from the first closed loop, wherein heat is transferred from the first fluid to the low quality feedwater so that the low quality fluid exits the heat exchanger assembly as a high-pressure steam and the first fluid exits the heat exchanger assembly as a condensed steam having a heat exchanger discharge temperature.

[0014] In particular embodiments, the low quality feedwater exits the heat exchanger assembly as supercritical steam.

[0015] Some methods further comprise sending the condensed steam in the first closed loop exiting the heat exchanger assembly to a deaerator for treatment prior to reintroducing the first fluid into the boiler. First fluid can also be sent from the boiler directly to the deaerator through a bypass segment. The first fluid in the bypass segment can be in the form of saturated steam.

[0016] The methods can further comprise providing additional first fluid to the first closed loop using a make-up feedwater system.

[0017] In embodiments, the boiler output temperature of the first fluid is at least 100°F greater than the temperature of the low-quality feedwater exiting the heat exchanger assembly.

[0018] These and other non-limiting characteristics are more particularly described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The following is a brief description of the drawings, which are presented for the purposes of illustrating the exemplary embodiments disclosed herein and not for the purposes of limiting the same.

[0020] **FIG. 1** is a flowchart showing the high-pressure steam generation system of the present disclosure. A first closed loop runs through a boiler and a heat exchanger assembly. A second loop that uses low quality feedwater also runs through the heat exchanger assembly.

[0021] **FIG. 2** is an exemplary illustration of a heat exchanger assembly containing heat exchangers arranged in series.

[0022] FIG. 3 is an exemplary illustration of a heat exchanger assembly containing heat exchangers arranged in parallel.

DETAILED DESCRIPTION

[0023] A more complete understanding of the components, processes, and apparatuses disclosed herein can be obtained by reference to the accompanying drawings. These figures are merely schematic representations based on convenience and the ease of demonstrating the present disclosure, and are, therefore, not intended to indicate relative size and dimensions of the devices or components thereof and/or to define or limit the scope of the exemplary embodiments.

[0024] Although specific terms are used in the following description for the sake of clarity, these terms are intended to refer only to the particular structure of the embodiments selected for illustration in the drawings, and are not intended to define or limit the scope of the disclosure. In the drawings and the following description below, it is to be understood that like numeric designations refer to components of like function.

[0025] The singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise.

[0026] As used in the specification and in the claims, the term "comprising" may include the embodiments "consisting of" and "consisting essentially of."

[0027] Numerical values should be understood to include numerical values which are the same when reduced to the same number of significant figures and numerical values which differ from the stated value by less than the experimental error of conventional measurement technique of the type described in the present application to determine the value.

[0028] All ranges disclosed herein are inclusive of the recited endpoint and independently combinable (for example, the range of "from 2 watts to 10 watts" is inclusive of the endpoints, 2 watts and 10 watts, and all the intermediate values).

[0029] As used herein, approximating language may be applied to modify any quantitative representation that may vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term or terms, such as "about" and "substantially," may not be limited to the precise value specified, in some

cases. The modifier "about" should also be considered as disclosing the range defined by the absolute values of the two endpoints. For example, the expression "from about 2 to about 4" also discloses the range "from 2 to 4."

[0030] The terms "waterside", "water cooled", "steam cooled" or "fluid side" refer to any area of the boiler that is exposed to water or steam. In contrast, the terms "airside", "gas side" or "fireside" refer to an area of the boiler that is exposed to direct heat from the furnace, or in other words the combustion air from the furnace. Where the specification refers to water and/or steam, the liquid and/or gaseous states of other fluids may also be used in the methods of the present disclosure.

[0031] The terms "inlet" and "outlet" are relative to a fluid flowing through them with respect to a given structure, e.g. a fluid flows through the inlet into the structure and flows through the outlet out of the structure. The terms "upstream" and "downstream" are relative to the direction in which a fluid flows through various components, i.e. the flow fluids through an upstream component prior to flowing through the downstream component. It should be noted that in a loop, a first component can be described as being both upstream of and downstream of a second component.

[0032] As used herein, the term "supercritical" refers to a fluid that is at a temperature above its critical temperature and at a pressure above its critical pressure. For example, the critical temperature of water is 374.15 °C (705°F), and the critical pressure of water is 3200.1 psia (22.1 MPa). A fluid at a temperature that is above its critical temperature at a given pressure but is below its critical pressure is considered to be "superheated" but "subcritical". A superheated fluid can be cooled (i.e. transfer energy) without changing its phase. As used herein, the term "wet steam" refers to a saturated steam/water mixture (i.e., steam with less than 100% quality where quality is percent steam content by mass). As used herein, the term "dry steam" refers to steam having a quality equal to greater than 100% (i.e., no liquid water is present). Supercritical water or steam will have no visible bubble interface or meniscus forming during a heating or cooling process due to zero surface tension on reaching the critical point temperature. The fluid continues to act like a single phase flow while converting from water to steam or steam to water, and is a non-equilibrium thermodynamic condition where rapid changes in density, viscosity and thermal conductivity can occur.

[0033] To the extent that explanations of certain terminology or principles of the boiler and/or steam generator arts may be necessary to understand the present disclosure, the reader is referred to *Steam/its generation and use*, 40th Edition, Stultz and Kitto, Eds., Copyright 1992, The Babcock & Wilcox Company, and to *Steam/its generation and use*, 41st Edition, Kitto and Stultz, Eds., Copyright 2005, The Babcock & Wilcox Company, the texts of which are hereby incorporated by reference as though fully set forth herein.

[0034] The present disclosure relates to systems and methods for generating high-pressure steam for a designated process, up to and including supercritical steam, using a low quality feedwater source without the need to treat large quantities of water on a continuous basis. The high-pressure steam is produced by passing the low quality feedwater through a heat exchanger assembly. There, heat energy from a high-temperature steam flow is transferred to the low quality feedwater. This arrangement minimizes the amount of effort spent on maintenance as deposits (e.g. scale) generally occur more in the heat exchanger assembly rather than in the boiler, as would occur if the low quality feedwater were directly heated by the boiler. This also minimizes the major expenses associated with the installation and operation of a high-volume high-purity water cleanup system that would otherwise be needed. The boiler water and steam cycle is decoupled from the process steam cycle.

[0035] FIG. 1 illustrates an exemplary embodiment of the steam generation system of the present disclosure. The steam generation system **100** includes a first loop **110** or piping arrangement. The first loop includes a boiler **120** and a heat exchanger assembly **130**.

[0036] The heat exchanger assembly **130** is downstream of the boiler **120**. The assembly includes a first fluid path and a second fluid path which are separate from each other, or in other words fluid in the first fluid path will not mix with fluid in the second fluid path. The two fluid paths are generally made to permit heat transfer from one fluid path to the other fluid path, e.g. in counter-current flow or cross-current flow patterns. The first fluid path has a first inlet **132** and a first outlet **134**. The second fluid path also has a second inlet **136** and a second outlet **138**.

[0037] Pipe **111** connects the boiler **120** to the first inlet **132** of the heat exchanger assembly. Pipes **112** and **113** lead from the heat exchanger assembly **130** through a condensate pump **162** to a deaerator **164**, with pipe **112** being connected to the first outlet **134** of the heat exchanger assembly. Pipes **114** and **115** lead from the deaerator **164** through a feedwater pump **166** back to the boiler **120**. A make-up feedwater system **168** is shown here as feeding into pipe **115** upstream of the boiler **120**. A bypass segment **116** also directly connects the boiler **120** to the deaerator **164**.

[0038] The steam generation system also includes a second loop **140** or piping arrangement. The second loop includes a pipe **141** that carries low-quality feedwater source **150** to the second inlet **136** of the heat exchanger assembly **130**. Pipe **142** connects to the second outlet **138**, and carries high-pressure steam from the heat exchanger assembly to the designated process for use.

[0039] In use, fuel **102** and air **104** are fed to the boiler **120**, and used to convert a first fluid in the first closed loop **110** into steam of desired quality (e.g. saturated, superheated, supercritical, etc.). In this regard, the boiler **120** should be understood to include economizer, reheater, and superheater surfaces that can be used to obtain the desired pressure and temperature of the resulting steam to be sent to the heat exchanger assembly.

[0040] Two possible steam outlets are depicted from the boiler **120**. The first outlet is designated using pipe **111**, and carries high temperature steam to the heat exchanger assembly **130**. The second outlet is designated using pipe **116**, and bypasses the heat exchanger assembly **130**, and is shown here connecting directly to deaerator **164**. Pipe **116** carries saturated or slightly superheated steam and is generally used when the desired heat load passing through pipe **111** is reduced or minimized. In the deaerator **164**, dissolved gases are removed from the received steam, and the steam/water is returned to the boiler through pipes **114** and **115**. The first fluid circulating in the first closed loop is generally high-purity (i.e. high-quality) water. Thus, the first closed loop **110** could also be described as containing two sub-loops. The first sub-loop runs through boiler **120**, pipe **111**, heat exchanger assembly **130**, pipe **112**, pump **162**, pipe **113**, deaerator **164**, pipe **114**, pump **166**, and pipe **115**. The second sub-loop runs through boiler **120**, pipe **116**, deaerator **164**, pipe **114**, pump **166**, and pipe **115**.

[0041] The second loop **140** uses low-quality feedwater. This low-quality feedwater **150** passes to heat exchanger assembly **130**, where the feedwater is converted into high-pressure steam by transferring the heat energy from the first closed loop (carried by pipe **111**) to the low quality feedwater. The temperature of the high-temperature steam entering through pipe **111** is greater than the temperature of the high-pressure steam exiting through pipe **142**, the difference being established by accepted heat exchanger design practice, heat transfer and thermodynamic principles. In particular embodiments, the temperature of the high-temperature steam entering through pipe **111** is at least 100°F greater than the temperature of the high-pressure steam exiting through pipe **142**.

[0042] The high-pressure steam then exits in pipe **142** to be used in process **151**. The high-pressure steam **142** may be used in the process, and may then be recycled back through the heat exchanger assembly **130**, or low-quality feedwater can be continuously obtained from a feedwater source and consumed in the process **151**. The high-temperature steam **111** in the first closed loop exits the heat exchanger assembly **130** as condensed steam in pipe **112**, and is recycled through boiler **120** as previously described. Again, the first fluid in the first closed loop does not mix with the low-quality feedwater in the second loop; they are kept separate, and heat is transferred between them through the heat exchanger assembly.

[0043] The heat exchanger assembly **130** can include more than one heat exchanger, i.e. a plurality of heat exchangers. It is contemplated that those heat exchangers can be organized in series, or can be organized into two or more parallel streams. Parallel streams permit heat exchange to continue through one stream of heat exchangers while another stream of heat exchangers undergoes maintenance.

[0044] In particular embodiments, it is contemplated that the heat exchangers in the heat exchanger assembly **130** are tube-shell heat exchangers, in which the high-quality feedwater of the first closed loop passes through the shell-side and the low-quality feedwater passes through the tube-side of the heat exchangers (i.e. counter-flow to each other). It is contemplated that any scale/deposits which occurs due to the low-quality feedwater would occur in the tubes of the heat exchanger(s). The tubes of the heat exchanger assembly are easier to clean/maintain compared to the tubes in the

boiler itself (e.g. easier to obtain physical access to the tubes or to replace the tubes without needing to shut down the entire system).

[0045] FIG. 2 illustrates an exemplary heat exchanger assembly **130** containing heat exchangers **210**, **220**, and **230** arranged in series. The first inlet **132**, first outlet **134**, second inlet **136**, and second outlet **138** of the two fluid paths are also labeled.

[0046] FIG. 3 illustrates an exemplary heat exchanger assembly **130** containing six heat exchangers **210**, **220**, **230**, **240**, **250**, and **260**. The heat exchangers are arranged into two parallel streams, with each stream containing three heat exchangers arranged in series. Valves **270**, **280** control the fluid flow. It is contemplated that fluid flow can proceed through both streams concurrently, or one stream at a time (with the heat exchangers in the other stream undergoing maintenance). The first inlet **132**, first outlet **134**, second inlet **136**, and second outlet **138** of the two fluid paths are also labeled. These two figures are intended to be exemplary, and other arrangements are contemplated to be within the scope of the present disclosure.

[0047] The boiler **120** can generally be any type of boiler, such as a fuel-fired boiler, an electric boiler, a supercritical boiler, a solar boiler, a nuclear boiler, etc. Suitable examples of the boiler include the FM boiler, PFI boiler, PFT boiler, and TSSG boilers offered by Babcock & Wilcox. The FM boiler can generate a steam flow of 10,000 to 260,000 lbs/hour, a steam temperature up to 850°F (454°C) depending on the fuel source, and a steam pressure up to 1250 psig (8.62 MPa). The PFI boiler can generate a steam flow of 100,000 to 700,000 lbs/hour, a steam temperature up to 960°F (516°C), and a steam pressure up to 1150 psig (7.9 MPa). The PFT boiler can generate a steam flow of 350,000 to 800,000 lbs/hour, a steam temperature up to 1000°F (538°C), and a steam pressure up to 1800 psig (12.4 MPa). The TSSG boiler can generate a steam flow of 300,000 to 1.2 million lbs/hour, can generate superheated steam, and provide an operating steam pressure from 600 psig (4.14 MPa) up to 2,000 psig (13.8 MPa).

[0048] In particular embodiments, the steam exiting the boiler through pipe **111** is a low-pressure high-temperature steam flow. This steam flow in pipe **111** may have a pressure of from about 50 psig to about 1800 psig and a temperature of from about 600°F to about 1000°F.

[0049] Similarly, in particular embodiments the steam in the second loop **140** exiting the heat exchanger assembly through pipe **142** is a high-pressure high-temperature steam flow, i.e. supercritical. This steam flow in pipe **142** may have a pressure of 3200.1 psia (22.1 MPa) or higher, and a temperature of 374.15°C or higher.

[0050] The first fluid located in the first closed loop **110** is high-quality, and the feedwater in the second loop **140** is low-quality. For reference, Table 1 provides a listing of the allowable limits of various materials in ultrapure (UP) water, typical requirements for industrial boilers, and potable water according to the Environmental Protection Agency (EPA).

Table 1.

Constituent	Ultra Pure Water	Industrial Boiler Water Requirements	EPA Potable Water
pH	8.0-9.6	8.8-9.6	6.5-8.5
Hydrazine	0-20 ppb	-	-
Total Dissolved Solids (TDS)	30 ppb	25 ppm*	500 ppm
Hardness	3 ppb	50 ppb	-
Organics	100-200 ppb	200 ppb	-
Sodium	3-5 ppb	-	-
Oxygen	7-150 ppb	7 ppb	-
Silica	10-20 ppb	-	-
Iron	5-10 ppb	20 ppb	0.3 ppm
Copper	0-2 ppb	10 ppb	1.3 ppm

* assumes 1000 psi, 0.1ppm solids in steam and 2% blowdown

[0051] It should be noted that the UltraPure water requirements are in parts per billion, whereas the EPA requires are in parts per million. Potable water is not clean/pure enough to be used as feedwater in a boiler. For the purposes of this application, "low-quality feedwater" is considered to be any fluid having more of a given constituent than permitted by the column entitled "Industrial Boiler Water Requirements." The fluid used in the first closed loop typically meets the requirements listed in the column entitled "Industrial Boiler Water Requirements" or "Ultra Pure Water", depending on the boiler used.

[0052] The present disclosure has been described with reference to exemplary embodiments. Obviously, modifications and alterations will occur to others upon

reading and understanding the preceding detailed description. It is intended that the present disclosure be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

CLAIMS:

1. A system for producing high-pressure steam from low quality feedwater, comprising:

a first closed loop containing a first fluid, the first closed loop containing a boiler and a heat exchanger assembly downstream of the boiler, wherein at least a portion of the first fluid exits the boiler as a high-temperature steam having a boiler output temperature; and

a second loop in fluid communication with the heat exchanger assembly, the second loop containing the low quality feedwater;

wherein the heat exchanger assembly is adapted to receive the first fluid from the boiler and transfer heat from the first fluid to the low quality feedwater in the second loop so that the low quality feedwater exits the heat exchanger assembly as a high-pressure steam and the first fluid exits the heat exchanger assembly as a condensed steam having a heat exchanger discharge temperature.

2. The system of claim 1, wherein the heat exchanger assembly includes a plurality of heat exchangers.

3. The system of claim 2, wherein at least two heat exchangers in the plurality of heat exchangers are arranged in parallel.

4. The system of claim 1, wherein the low quality feedwater exits the heat exchanger assembly as supercritical steam.

5. The system of claim 1, wherein the first closed loop further comprises a deaerator downstream of the heat exchanger assembly for treating the condensed steam prior to reintroducing the first fluid into the boiler.

6. The system of claim 5, further comprising a bypass segment directly connecting the boiler and the deaerator.

7. The system of claim 6, wherein the first fluid in the bypass segment is in the form of saturated steam.

8. The system of claim 1, wherein the first closed loop further comprises a make-up feedwater system for providing additional first fluid.

9. The system of claim 1, wherein the boiler output temperature of the first fluid is at least 100°F greater than the temperature of the low-quality feedwater exiting the heat exchanger assembly.

10. A method for producing high-pressure steam from low quality feedwater, the method comprising:

heating a first fluid in a boiler, wherein at least a portion of the first fluid exits the boiler as a high-temperature steam having a boiler output temperature;

sending the high-temperature steam to a heat exchanger assembly, the boiler and the heat exchanger assembly forming a first closed loop; and

sending the low quality feedwater to the heat exchanger assembly, the low quality feedwater being in a second loop separate from the first closed loop, wherein heat is transferred from the first fluid to the low quality feedwater so that the low quality fluid exits the heat exchanger assembly as a high-pressure steam and the first fluid exits the heat exchanger assembly as a condensed steam having a heat exchanger discharge temperature.

11. The method of claim 10, wherein the heat exchanger assembly includes a plurality of heat exchangers.

12. The method of claim 11, wherein at least two heat exchangers in the plurality of heat exchangers are arranged in parallel.

13. The method of claim 10, wherein the low quality feedwater exits the heat exchanger assembly as supercritical steam.

14. The method of claim 10, further comprising sending the condensed steam in the first closed loop exiting the heat exchanger assembly to a deaerator for treatment prior to reintroducing the first fluid into the boiler.

15. The method of claim 14, further comprising sending first fluid from the boiler directly to the deaerator through a bypass segment.

16. The method of claim 15, wherein the first fluid in the bypass segment is in the form of saturated steam.

17. The method of claim 10, further comprising providing additional first fluid to the first closed loop using a make-up feedwater system.

18. The method of claim 10, wherein the boiler output temperature of the first fluid is at least 100°F greater than the temperature of the low-quality feedwater exiting the heat exchanger assembly.

SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER

ABSTRACT OF THE DISCLOSURE

The present disclosure relates to a system for producing high pressure steam from low quality feedwater for a designated process. The system includes a first closed loop in fluid communication with a boiler and a heat exchanger assembly. A first fluid flows through the first closed loop, and is of acceptable quality for use in a boiler. Heat from the boiler is transferred to a second loop through the heat exchanger assembly. The second loop includes the low quality feedwater, which is converted to high pressure steam. The high pressure steam produced from the low quality water can be used in the designated process. This reduces corrosion / downtime in the boiler that might otherwise occur if the low quality water was directly heated by the boiler.

BWPG 200051USP1 607481 3

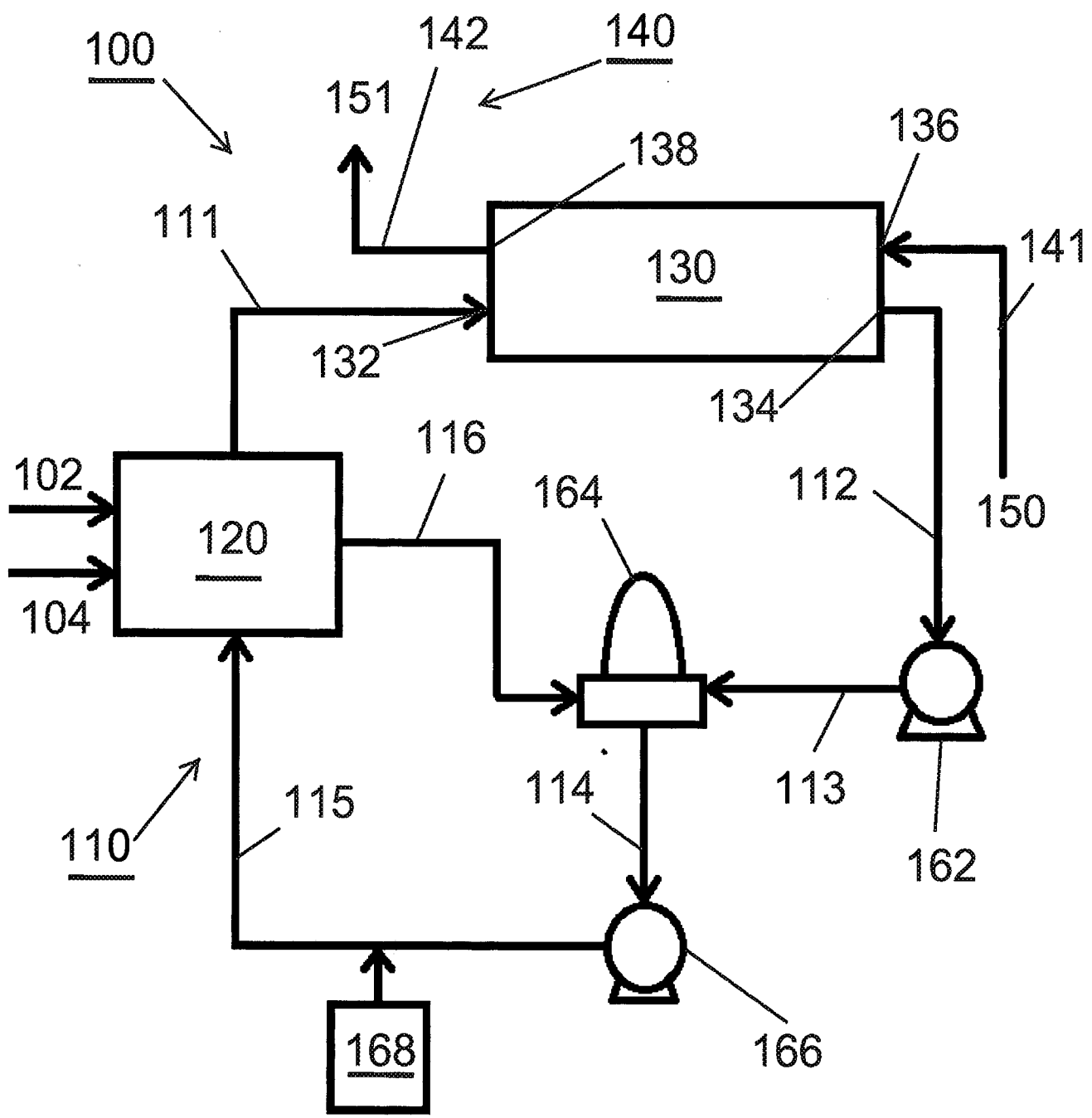


FIG. 1

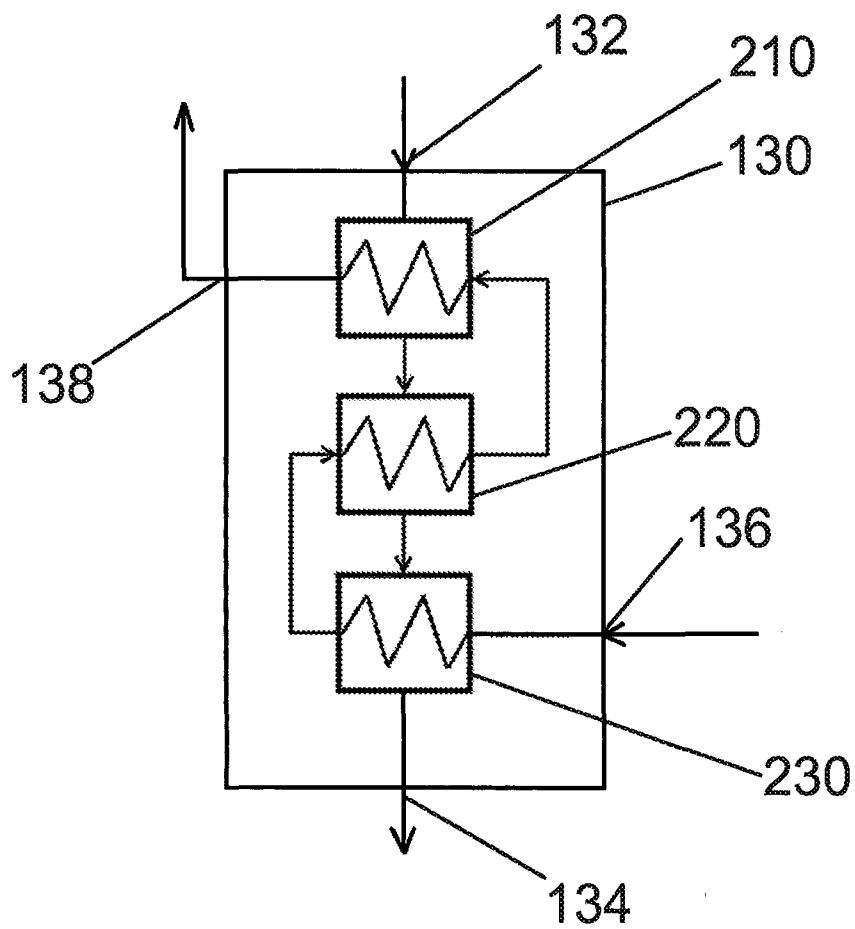


FIG. 2

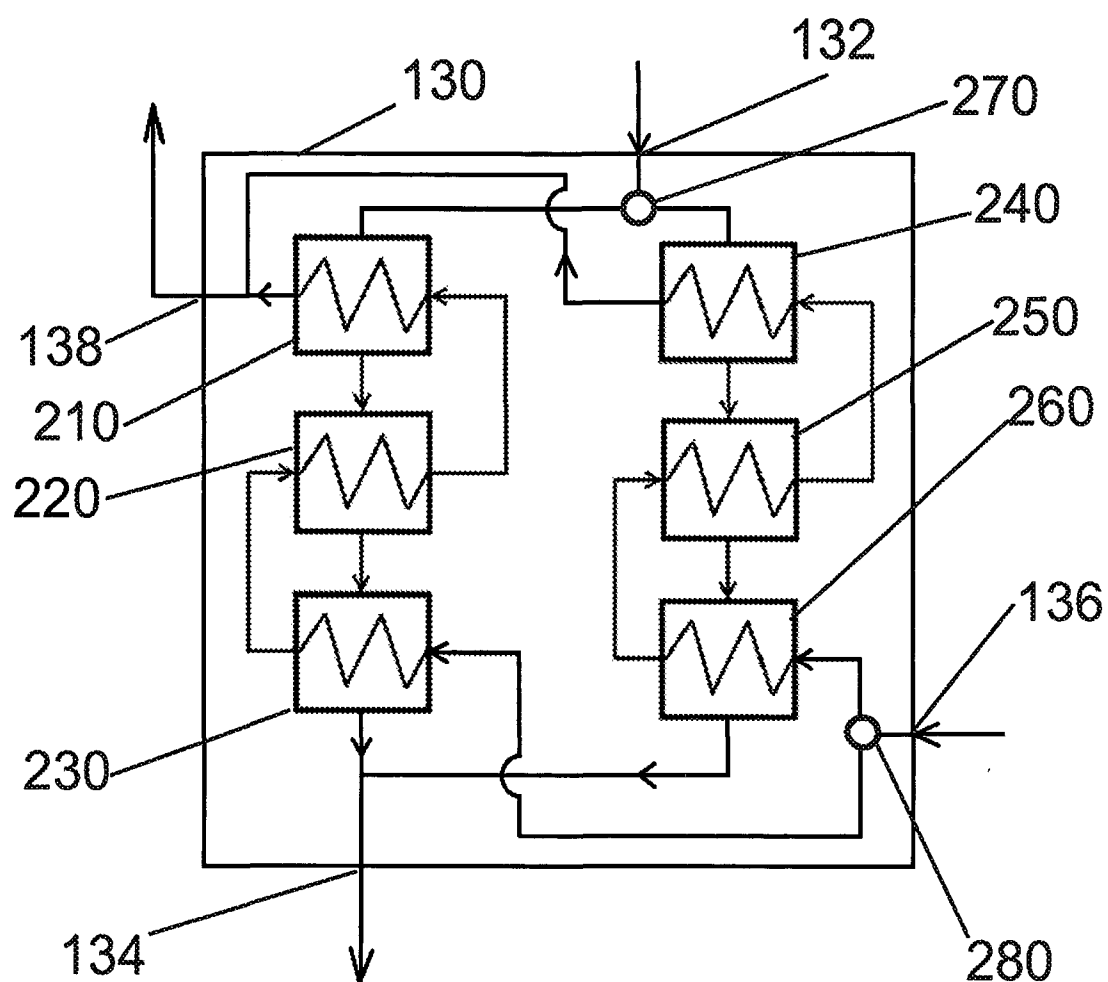


FIG. 3

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Case 7564
		Application Number	
Title of Invention	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1					Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Donald	E	RYAN		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Diamond	State/Province	OH	Country of Residence i	US
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Address 2					
City	Diamond	State/Province	OH		
Postal Code	44412	Country i	US		
Inventor 2					Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	James	S	KULIG		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
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Mailing Address of Inventor:					
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Address 2					
City	Medina	State/Province	OH		
Postal Code	44256	Country i	US		
Inventor 3					Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Larry	A	PIERSON		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Case 7564		
		Application Number			
Title of Invention	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER				
City	Uniontown	State/Province	OH	Country of Residence i	US
Mailing Address of Inventor:					
Address 1		3945 Orangewood Way			
Address 2					
City	Uniontown	State/Province		OH	
Postal Code	44685	Country i	US		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.					Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).	
☐ An Address is being provided for the correspondence Information of this application.	
Customer Number	41669
Email Address	Add Email Remove Email

Application Information:

Title of the Invention	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER		
Attorney Docket Number	Case 7564	Small Entity Status Claimed ☐	
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	1	Suggested Figure for Publication (if any)	3

Filing By Reference :

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country i

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐ Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Case 7564
		Application Number	
Title of Invention	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER		

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.			
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Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78. When referring to the current application, please leave the application number blank.			
Prior Application Status	Pending	Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Claims benefit of provisional	61/842157	2013-07-02
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.			Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).			
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Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ^j (if applicable)
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Case 7564
		Application Number	
Title of Invention	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER		

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. ☐ NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.
--

Authorization to Permit Access:

☐ Authorization to Permit Access to the Instant Application by the Participating Offices If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application. In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application. In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.
--

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Case 7564
		Application Number	
Title of Invention	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER		

Applicant 1				Remove	
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.					
Clear					
☐ Assignee		☐ Legal Representative under 35 U.S.C. 117		☐ Joint Inventor	
☒ Person to whom the inventor is obligated to assign.			☐ Person who shows sufficient proprietary interest		
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:					
Name of the Deceased or Legally Incapacitated Inventor :					
If the Applicant is an Organization check here. ☒					
Organization Name		Babcock & Wilcox Power Generation Group, Inc.			
Mailing Address information:					
Address 1		20 S. Van Buren Avenue			
Address 2					
City		Barberton	State/Province		OH
Country ⁱ		US	Postal Code		44203
Phone Number			Fax Number		
Email Address					
Additional Applicant Data may be generated within this form by selecting the Add button. Add					

Assignee Information including Non-Applicant Assignee Information:

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Assignee 1	
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.	
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Case 7564
		Application Number	
Title of Invention	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER		

Prefix	Given Name	Middle Name	Family Name	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:				
Address 1				
Address 2				
City			State/Province	
Country i			Postal Code	
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Signature	/emarich/			Date (YYYY-MM-DD)	2014-06-06
First Name	Eric	Last Name	Marich	Registration Number	32265
Additional Signature may be generated within this form by selecting the Add button.					Add

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

3A

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09 de julio de 2014

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NÚMERO DE SOLICITUD: 61/842,157

FECHA DE PRESENTACIÓN: 02 de julio de 2013

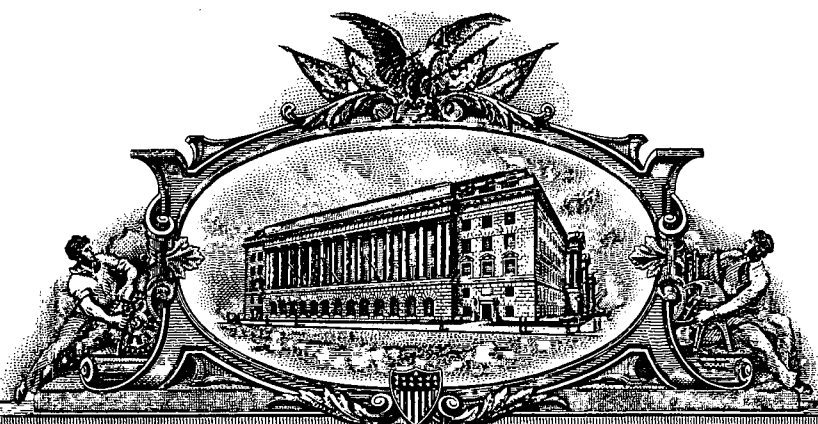
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Oficial de Registro

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July 09, 2014

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APPLICATION NUMBER: 61/842,157

FILING DATE: July 02, 2013

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS US61/842,157

By Authority of the

Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office



T. Wallace
T. WALLACE
Certifying Officer

Electronic Acknowledgement Receipt

EFS ID:	16220630
Application Number:	61842157
International Application Number:	
Confirmation Number:	2130
Title of Invention:	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER
First Named Inventor/Applicant Name:	Donald E Ryan
Customer Number:	41669
Filer:	Eric Marich/Amy Saus
Filer Authorized By:	Eric Marich
Attorney Docket Number:	Case 7564-P
Receipt Date:	02-JUL-2013
Filing Date:	
Time Stamp:	16:26:53
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	\$ 260
RAM confirmation Number	3551
Deposit Account	501813
Authorized User	

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37

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Provisional Cover Sheet (SB16)	Case_7564-P_Pro_Cover_Sheet_Provisional ISB.pdf	1477290	no	3
			e79a1b965fdea88ef805f2c77208fef927c5198a		
Warnings:					
Information:					
2		Case_7564-P_App_FINAL.pdf	219184	yes	15
			90e896232b2adcf69556d0599511fe041c67fb74		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	11	
	Claims		12	14	
	Abstract		15	15	
Warnings:					
Information:					
3	Drawings-only black and white line drawings	Case_7564-P_Figs_FINAL.pdf	42198	no	3
			0e19197ccd66e590cf3fd79d1338e759050630c3		
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	29722	no	2
			8963ee647598285ee6bc8957ba5f19e373a7791b		
Warnings:					
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New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

3a

Doc Code: **TR.PROV**
Document Description: Provisional Cover Sheet (SB16)

PTO/SB/16 (11-08)
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Provisional Application for Patent Cover Sheet
This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

Inventor(s)					
Inventor 1					Remove
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Donald	E	Ryan	Diamond	OH	US

All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.

Title of Invention	SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER
Attorney Docket Number (if applicable)	Case 7564-P

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Signature	/emarich/			Date (YYYY-MM-DD)	2013-07-02
First Name	Eric	Last Name	Marich	Registration Number (If appropriate)	32265

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SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER

BACKGROUND

[0001] The present disclosure relates to systems and methods for producing high pressure steam using a poor or low quality feedwater source. This can be accomplished without continuously treating large quantities of water.

[0002] During combustion, the chemical energy in a fuel is converted to thermal heat inside the furnace of a boiler. The thermal heat is captured through heat-absorbing surfaces in the boiler to produce steam. The fuels used in the furnace include a wide range of solid, liquid, and gaseous substances, including coal, natural gas, and diesel oil.

[0003] Steam generation from a boiler system involves thermal and physical processes of heat transfer, fluid flow, evaporation, and condensation of a feedwater fluid mixture that includes water and steam. As the temperatures and pressures of the feedwater and the produced steam change, dissolved materials in the water can precipitate and/or deposit in the waterside of the boiler. These include materials such as oxides, hydroxides, hydrates, carbonates, and other organic/chemical impurities. These deposits can result in the formation of scale on the insides of tube surfaces, or can facilitate corrosion of structural materials within the boiler system. These deposits and /or corrosion combined with the high heat fluxes found in the furnace section of a boiler may lead to tube failures. While scale/deposits can be removed using various maintenance and clean-up processes, this leads to downtime.

[0004] Typical systems for supplying high-pressure high-temperature steam to various processes generally involve the direct heating of the feedwater in the boiler. High purity feedwater is typically required to avoid scale/deposits within the tubes of the boiler, other devices associated with the system, and the piping in fluid communication therewith. Low quality feedwater can be treated/cleaned to obtain high purity feedwater. While this is acceptable in a closed loop where the treated high purity feedwater is recycled through the boiler, the treatment/clean-up of the feedwater becomes prohibitively expensive in an open loop cycle because the feedwater treatment system

would need to continuously produce high purity water at a rate that is equal to the steam flow requirement of the process. Otherwise, the heat flux in the boiler tubes caused by using low quality feedwater would result in deposits/accumulation of impurities.

[0005] However, not all commercial processes that require high-pressure steam also require the steam be at as high a level of purity as the feedwater for a boiler system. It would be desirable to provide systems and methods that can produce high-pressure steam without the concurrent need to continuously produce or use high quality feedwater, and without increasing boiler downtime or maintenance.

BRIEF DESCRIPTION

[0006] The present disclosure relates to a system for producing high pressure steam from low quality feedwater for a designated process. The system includes a first closed loop piping system in fluid communication with a boiler and a heat exchanger assembly. A first fluid is provided within the first closed loop piping system, and a portion of the first fluid exits the boiler as high-temperature steam having a boiler output temperature. A second loop piping system for the designated process is in fluid communication with the heat exchanger assembly, and contains the low quality feedwater. The heat from the first fluid is transferred to the low quality feedwater through the heat exchanger. The first piping system and second piping system are not in fluid communication, i.e. the first fluid and the low quality feedwater do not mix together.

[0007] Disclosed in some embodiments are systems for producing high-pressure steam from low quality feedwater, comprising: a first closed loop containing a first fluid, the first closed loop containing a boiler and a heat exchanger assembly downstream of the boiler, wherein at least a portion of the first fluid exits the boiler as a high-temperature steam having a boiler output temperature; and a second loop in fluid communication with the heat exchanger assembly, the second loop containing the low quality feedwater; wherein the heat exchanger assembly is adapted to receive the first fluid from the boiler and transfer heat from the first fluid to the low quality feedwater in the second loop so that the low quality feedwater exits the heat exchanger assembly as a high-pressure steam and the first fluid exits the heat exchanger assembly as a condensed steam having a heat exchanger discharge temperature.

[0008] The heat exchanger assembly may include a plurality of heat exchangers. Those heat exchangers can be arranged in series or parallel. In particular embodiments, at least two heat exchangers in the plurality of heat exchangers are arranged in parallel.

[0009] The low quality feedwater can exit the heat exchanger assembly as supercritical steam.

[0010] The first closed loop can further comprise a deaerator downstream of the heat exchanger assembly for treating the condensed steam prior to reintroducing the first fluid into the boiler. The system may include a bypass segment directly connecting the boiler and the deaerator. The first fluid in the bypass segment may be in the form of saturated steam. The first closed loop can also further comprise a make-up feedwater system for providing additional first fluid.

[0011] In particular embodiments, the boiler output temperature of the first fluid is at least 100°F greater than the temperature of the low-quality feedwater exiting the heat exchanger assembly.

[0012] Also disclosed herein are methods for producing high-pressure steam from low quality feedwater, comprising: heating a first fluid in a boiler, wherein at least a portion of the first fluid exits the boiler as a high-temperature steam having a boiler output temperature; sending the high-temperature steam to a heat exchanger assembly, the boiler and the heat exchanger assembly forming a first closed loop; and sending the low quality feedwater to the heat exchanger assembly, the low quality feedwater being in a second loop separate from the first closed loop, wherein heat is transferred from the first fluid to the low quality feedwater so that the low quality fluid exits the heat exchanger assembly as a high-pressure steam and the first fluid exits the heat exchanger assembly as a condensed steam having a heat exchanger discharge temperature.

[0013] In particular embodiments, the low quality feedwater exits the heat exchanger assembly as supercritical steam.

[0014] Some methods further comprise sending the condensed steam in the first closed loop exiting the heat exchanger assembly to a deaerator for treatment prior to reintroducing the first fluid into the boiler. First fluid can also be sent from the boiler

directly to the deaerator through a bypass segment. The first fluid in the bypass segment can be in the form of saturated steam.

[0015] The methods can further comprise providing additional first fluid to the first closed loop using a make-up feedwater system.

[0016] In embodiments, the boiler output temperature of the first fluid is at least 100°F greater than the temperature of the low-quality feedwater exiting the heat exchanger assembly.

[0017] These and other non-limiting characteristics are more particularly described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The following is a brief description of the drawings, which are presented for the purposes of illustrating the exemplary embodiments disclosed herein and not for the purposes of limiting the same.

[0019] **FIG. 1** is a flowchart showing the high-pressure steam generation system of the present disclosure. A first closed loop runs through a boiler and a heat exchanger assembly. A second loop that uses low quality feedwater also runs through the heat exchanger assembly.

[0020] **FIG. 2** is an exemplary illustration of a heat exchanger assembly containing heat exchangers arranged in series.

[0021] **FIG. 3** is an exemplary illustration of a heat exchanger assembly containing heat exchangers arranged in parallel.

DETAILED DESCRIPTION

[0022] A more complete understanding of the components, processes, and apparatuses disclosed herein can be obtained by reference to the accompanying drawings. These figures are merely schematic representations based on convenience and the ease of demonstrating the present disclosure, and are, therefore, not intended to indicate relative size and dimensions of the devices or components thereof and/or to define or limit the scope of the exemplary embodiments.

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[0023] Although specific terms are used in the following description for the sake of clarity, these terms are intended to refer only to the particular structure of the embodiments selected for illustration in the drawings, and are not intended to define or limit the scope of the disclosure. In the drawings and the following description below, it is to be understood that like numeric designations refer to components of like function.

[0024] The singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise.

[0025] As used in the specification and in the claims, the term "comprising" may include the embodiments "consisting of" and "consisting essentially of."

[0026] Numerical values should be understood to include numerical values which are the same when reduced to the same number of significant figures and numerical values which differ from the stated value by less than the experimental error of conventional measurement technique of the type described in the present application to determine the value.

[0027] All ranges disclosed herein are inclusive of the recited endpoint and independently combinable (for example, the range of "from 2 watts to 10 watts" is inclusive of the endpoints, 2 watts and 10 watts, and all the intermediate values).

[0028] As used herein, approximating language may be applied to modify any quantitative representation that may vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term or terms, such as "about" and "substantially," may not be limited to the precise value specified, in some cases. The modifier "about" should also be considered as disclosing the range defined by the absolute values of the two endpoints. For example, the expression "from about 2 to about 4" also discloses the range "from 2 to 4."

[0029] The terms "waterside", "water cooled", "steam cooled" or "fluid side" refer to any area of the boiler that is exposed to water or steam. In contrast, the terms "airside", "gas side" or "fireside" refer to an area of the boiler that is exposed to direct heat from the furnace, or in other words the combustion air from the furnace. Where the specification refers to water and/or steam, the liquid and/or gaseous states of other fluids may also be used in the methods of the present disclosure.

[0030] The terms “inlet” and “outlet” are relative to a fluid flowing through them with respect to a given structure, e.g. a fluid flows through the inlet into the structure and flows through the outlet out of the structure. The terms “upstream” and “downstream” are relative to the direction in which a fluid flows through various components, i.e. the flow fluids through an upstream component prior to flowing through the downstream component. It should be noted that in a loop, a first component can be described as being both upstream of and downstream of a second component.

[0031] As used herein, the term “supercritical” refers to a fluid that is at a temperature above its critical temperature and at a pressure above its critical pressure. For example, the critical temperature of water is 374.15 °C (705°F), and the critical pressure of water is 3200.1 psia (22.1 MPa). A fluid at a temperature that is above its critical temperature at a given pressure but is below its critical pressure is considered to be “superheated” but “subcritical”. A superheated fluid can be cooled (i.e. transfer energy) without changing its phase. As used herein, the term “wet steam” refers to a saturated steam/water mixture (i.e., steam with less than 100% quality where quality is percent steam content by mass). As used herein, the term “dry steam” refers to steam having a quality equal to greater than 100% (i.e., no liquid water is present). Supercritical water or steam will have no visible bubble interface or meniscus forming during a heating or cooling process due to zero surface tension on reaching the critical point temperature. The fluid continues to act like a single phase flow while converting from water to steam or steam to water, and is a non-equilibrium thermodynamic condition where rapid changes in density, viscosity and thermal conductivity can occur.

[0032] To the extent that explanations of certain terminology or principles of the boiler and/or steam generator arts may be necessary to understand the present disclosure, the reader is referred to *Steam/its generation and use*, 40th Edition, Stultz and Kitto, Eds., Copyright 1992, The Babcock & Wilcox Company, and to *Steam/its generation and use*, 41st Edition, Kitto and Stultz, Eds., Copyright 2005, The Babcock & Wilcox Company, the texts of which are hereby incorporated by reference as though fully set forth herein.

[0033] The present disclosure relates to systems and methods for generating high-pressure steam for a designated process, up to and including supercritical steam, using

a low quality feedwater source without the need to treat large quantities of water on a continuous basis. The high-pressure steam is produced by passing the low quality feedwater through a heat exchanger assembly. There, heat energy from a high-temperature steam flow is transferred to the low quality feedwater. This arrangement minimizes the amount of effort spent on maintenance as deposits (e.g. scale) generally occur more in the heat exchanger assembly rather than in the boiler, as would occur if the low quality feedwater were directly heated by the boiler. This also minimizes the major expenses associated with the installation and operation of a high-volume high-purity water cleanup system that would otherwise be needed. The boiler water and steam cycle is decoupled from the process steam cycle.

[0034] FIG. 1 illustrates an exemplary embodiment of the steam generation system of the present disclosure. The steam generation system **100** includes a first loop **110** or piping arrangement. The first loop includes a boiler **120** and a heat exchanger assembly **130**.

[0035] The heat exchanger assembly **130** is downstream of the boiler **120**. The assembly includes a first fluid path and a second fluid path which are separate from each other, or in other words fluid in the first fluid path will not mix with fluid in the second fluid path. The two fluid paths are generally made to permit heat transfer from one fluid path to the other fluid path, e.g. in counter-current flow or cross-current flow patterns. The first fluid path has a first inlet **132** and a first outlet **134**. The second fluid path also has a second inlet **136** and a second outlet **138**.

[0036] Pipe **111** connects the boiler **120** to the first inlet **132** of the heat exchanger assembly. Pipes **112** and **113** lead from the heat exchanger assembly **130** through a condensate pump **162** to a deaerator **164**, with pipe **112** being connected to the first outlet **134** of the heat exchanger assembly. Pipes **114** and **115** lead from the deaerator **164** through a feedwater pump **166** back to the boiler **120**. A make-up feedwater system **168** is shown here as feeding into pipe **115** upstream of the boiler **120**. A bypass segment **116** also directly connects the boiler **120** to the deaerator **164**.

[0037] The steam generation system also includes a second loop **140** or piping arrangement. The second loop includes a pipe **141** that carries low-quality feedwater source **150** to the second inlet **136** of the heat exchanger assembly **130**. Pipe **142**

connects to the second outlet **138**, and carries high-pressure steam from the heat exchanger assembly to the designated process for use.

[0038] In use, fuel **102** and air **104** are fed to the boiler **120**, and used to convert a first fluid in the first closed loop **110** into steam of desired quality (e.g. saturated, superheated, supercritical, etc.). In this regard, the boiler **120** should be understood to include economizer, reheater, and superheater surfaces that can be used to obtain the desired pressure and temperature of the resulting steam to be sent to the heat exchanger assembly.

[0039] Two possible steam outlets are depicted from the boiler **120**. The first outlet is designated using pipe **111**, and carries high temperature steam to the heat exchanger assembly **130**. The second outlet is designated using pipe **116**, and bypasses the heat exchanger assembly **130**, and is shown here connecting directly to deaerator **164**. Pipe **116** carries saturated or slightly superheated steam and is generally used when the desired heat load passing through pipe **111** is reduced or minimized. In the deaerator **164**, dissolved gases are removed from the received steam, and the steam/water is returned to the boiler through pipes **114** and **115**. The first fluid circulating in the first closed loop is generally high-purity (i.e. high-quality) water. Thus, the first closed loop **110** could also be described as containing two sub-loops. The first sub-loop runs through boiler **120**, pipe **111**, heat exchanger assembly **130**, pipe **112**, pump **162**, pipe **113**, deaerator **164**, pipe **114**, pump **166**, and pipe **115**. The second sub-loop runs through boiler **120**, pipe **116**, deaerator **164**, pipe **114**, pump **166**, and pipe **115**,

[0040] The second loop **140** uses low-quality feedwater. This low-quality feedwater **150** passes to heat exchanger assembly **130**, where the feedwater is converted into high-pressure steam by transferring the heat energy from the first closed loop (carried by pipe **111**) to the low quality feedwater. The temperature of the high-temperature steam entering through pipe **111** is greater than the temperature of the high-pressure steam exiting through pipe **142**, the difference being established by accepted heat exchanger design practice, heat transfer and thermodynamic principles. In particular embodiments, the temperature of the high-temperature steam entering through pipe **111** is at least 100°F greater than the temperature of the high-pressure steam exiting through pipe **142**.

[0041] The high-pressure steam then exits in pipe **142** to be used in process **151**. The high-pressure steam **142** may be used in the process, and may then be recycled back through the heat exchanger assembly **130**, or low-quality feedwater can be continuously obtained from a feedwater source and consumed in the process **151**. The high-temperature steam **111** in the first closed loop exits the heat exchanger assembly **130** as condensed steam in pipe **112**, and is recycled through boiler **120** as previously described. Again, the first fluid in the first closed loop does not mix with the low-quality feedwater in the second loop; they are kept separate, and heat is transferred between them through the heat exchanger assembly.

[0042] The heat exchanger assembly **130** can include more than one heat exchanger, i.e. a plurality of heat exchangers. It is contemplated that those heat exchangers can be organized in series, or can be organized into two or more parallel streams. Parallel streams permit heat exchange to continue through one stream of heat exchangers while another stream of heat exchangers undergoes maintenance.

[0043] In particular embodiments, it is contemplated that the heat exchangers in the heat exchanger assembly **130** are tube-shell heat exchangers, in which the high-quality feedwater of the first closed loop passes through the shell-side and the low-quality feedwater passes through the tube-side of the heat exchangers (i.e. counter-flow to each other). It is contemplated that any scale/deposits which occurs due to the low-quality feedwater would occur in the tubes of the heat exchanger(s). The tubes of the heat exchanger assembly are easier to clean/maintain compared to the tubes in the boiler itself (e.g. easier to obtain physical access to the tubes or to replace the tubes without needing to shut down the entire system).

[0044] FIG. 2 illustrates an exemplary heat exchanger assembly **130** containing heat exchangers **210**, **220**, and **230** arranged in series. The first inlet **132**, first outlet **134**, second inlet **136**, and second outlet **138** of the two fluid paths are also labeled.

[0045] FIG. 3 illustrates an exemplary heat exchanger assembly **130** containing six heat exchangers **210**, **220**, **230**, **240**, **250**, and **260**. The heat exchangers are arranged into two parallel streams, with each stream containing three heat exchangers arranged in series. Valves **270**, **280** control the fluid flow. It is contemplated that fluid flow can proceed through both streams concurrently, or one stream at a time (with the heat

exchangers in the other stream undergoing maintenance). The first inlet **132**, first outlet **134**, second inlet **136**, and second outlet **138** of the two fluid paths are also labeled. These two figures are intended to be exemplary, and other arrangements are contemplated to be within the scope of the present disclosure.

[0046] The boiler **120** can generally be any type of boiler, such as a fuel-fired boiler, an electric boiler, a supercritical boiler, a solar boiler, a nuclear boiler, etc. Suitable examples of the boiler include the FM boiler, PFI boiler, PFT boiler, and TSSG boilers offered by Babcock & Wilcox. The FM boiler can generate a steam flow of 10,000 to 260,000 lbs/hour, a steam temperature up to 850°F (454°C) depending on the fuel source, and a steam pressure up to 1250 psig (8.62 MPa). The PFI boiler can generate a steam flow of 100,000 to 700,000 lbs/hour, a steam temperature up to 960°F (516°C), and a steam pressure up to 1150 psig (7.9 MPa). The PFT boiler can generate a steam flow of 350,000 to 800,000 lbs/hour, a steam temperature up to 1000°F (538°C), and a steam pressure up to 1800 psig (12.4 MPa). The TSSG boiler can generate a steam flow of 300,000 to 1.2 million lbs/hour, can generate superheated steam, and provide an operating steam pressure from 600 psig (4.14 MPa) up to 2,000 psig (13.8 MPa).

[0047] In particular embodiments, the steam exiting the boiler through pipe **111** is a low-pressure high-temperature steam flow. This steam flow in pipe **111** may have a pressure of from about 50 psig to about 1800 psig and a temperature of from about 600°F to about 1000°F.

[0048] Similarly, in particular embodiments the steam in the second loop **140** exiting the heat exchanger assembly through pipe **142** is a high-pressure high-temperature steam flow, i.e. supercritical. This steam flow in pipe **142** may have a pressure of 3200.1 psia (22.1 MPa) or higher, and a temperature of 374.15°C or higher.

[0049] The first fluid located in the first closed loop **110** is high-quality, and the feedwater in the second loop **140** is low-quality. For reference, Table 1 provides a listing of the allowable limits of various materials in ultrapure (UP) water, typical requirements for industrial boilers, and potable water according to the Environmental Protection Agency (EPA).

Table 1.

Constituent	Ultra Pure Water	Industrial Boiler Water Requirements	EPA Potable Water
pH	8.0-9.6	8.8-9.6	6.5-8.5
Hydrazine	0-20 ppb	-	-
Total Dissolved Solids (TDS)	30 ppb	25 ppm*	500 ppm
Hardness	3 ppb	50 ppb	-
Organics	100-200 ppb	200 ppb	-
Sodium	3-5 ppb	-	-
Oxygen	7-150 ppb	7 ppb	-
Silica	10-20 ppb	-	-
Iron	5-10 ppb	20 ppb	0.3 ppm
Copper	0-2 ppb	10 ppb	1.3 ppm

* assumes 1000 psi, 0.1ppm solids in steam and 2% blowdown

[0050] It should be noted that the UltraPure water requirements are in parts per billion, whereas the EPA requires are in parts per million. Potable water is not clean/pure enough to be used as feedwater in a boiler. For the purposes of this application, "low-quality feedwater" is considered to be any fluid having more of a given constituent than permitted by the column entitled "Industrial Boiler Water Requirements." The fluid used in the first closed loop typically meets the requirements listed in the column entitled "Industrial Boiler Water Requirements" or "Ultra Pure Water", depending on the boiler used.

[0051] The present disclosure has been described with reference to exemplary embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the present disclosure be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

CLAIMS:

1. A system for producing high-pressure steam from low quality feedwater, comprising:

a first closed loop containing a first fluid, the first closed loop containing a boiler and a heat exchanger assembly downstream of the boiler, wherein at least a portion of the first fluid exits the boiler as a high-temperature steam having a boiler output temperature; and

a second loop in fluid communication with the heat exchanger assembly, the second loop containing the low quality feedwater;

wherein the heat exchanger assembly is adapted to receive the first fluid from the boiler and transfer heat from the first fluid to the low quality feedwater in the second loop so that the low quality feedwater exits the heat exchanger assembly as a high-pressure steam and the first fluid exits the heat exchanger assembly as a condensed steam having a heat exchanger discharge temperature.

2. The system of claim 1, wherein the heat exchanger assembly includes a plurality of heat exchangers.

3. The system of claim 2, wherein at least two heat exchangers in the plurality of heat exchangers are arranged in parallel.

4. The system of claim 1, wherein the low quality feedwater exits the heat exchanger assembly as supercritical steam.

5. The system of claim 1, wherein the first closed loop further comprises a deaerator downstream of the heat exchanger assembly for treating the condensed steam prior to reintroducing the first fluid into the boiler.

6. The system of claim 5, further comprising a bypass segment directly connecting the boiler and the deaerator.

7. The system of claim 6, wherein the first fluid in the bypass segment is in the form of saturated steam.

8. The system of claim 1, wherein the first closed loop further comprises a make-up feedwater system for providing additional first fluid.

9. The system of claim 1, wherein the boiler output temperature of the first fluid is at least 100°F greater than the temperature of the low-quality feedwater exiting the heat exchanger assembly.

10. A method for producing high-pressure steam from low quality feedwater, the method comprising:

heating a first fluid in a boiler, wherein at least a portion of the first fluid exits the boiler as a high-temperature steam having a boiler output temperature;

sending the high-temperature steam to a heat exchanger assembly, the boiler and the heat exchanger assembly forming a first closed loop; and

sending the low quality feedwater to the heat exchanger assembly, the low quality feedwater being in a second loop separate from the first closed loop, wherein heat is transferred from the first fluid to the low quality feedwater so that the low quality fluid exits the heat exchanger assembly as a high-pressure steam and the first fluid exits the heat exchanger assembly as a condensed steam having a heat exchanger discharge temperature.

11. The method of claim 10, wherein the heat exchanger assembly includes a plurality of heat exchangers.

12. The method of claim 11, wherein at least two heat exchangers in the plurality of heat exchangers are arranged in parallel.

13. The method of claim 10, wherein the low quality feedwater exits the heat exchanger assembly as supercritical steam.

14. The method of claim 10, further comprising sending the condensed steam in the first closed loop exiting the heat exchanger assembly to a deaerator for treatment prior to reintroducing the first fluid into the boiler.

15. The method of claim 14, further comprising sending first fluid from the boiler directly to the deaerator through a bypass segment.

16. The method of claim 15, wherein the first fluid in the bypass segment is in the form of saturated steam.

17. The method of claim 10, further comprising providing additional first fluid to the first closed loop using a make-up feedwater system.

18. The method of claim 10, wherein the boiler output temperature of the first fluid is at least 100°F greater than the temperature of the low-quality feedwater exiting the heat exchanger assembly.

SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER

ABSTRACT OF THE DISCLOSURE

The present disclosure relates to a system for producing high pressure steam from low quality feedwater for a designated process. The system includes a first closed loop in fluid communication with a boiler and a heat exchanger assembly. A first fluid flows through the first closed loop, and is of acceptable quality for use in a boiler. Heat from the boiler is transferred to a second loop through the heat exchanger assembly. The second loop includes the low quality feedwater, which is converted to high pressure steam. The high pressure steam produced from the low quality water can be used in the designated process. This reduces corrosion / downtime in the boiler that might otherwise occur if the low quality water was directly heated by the boiler.

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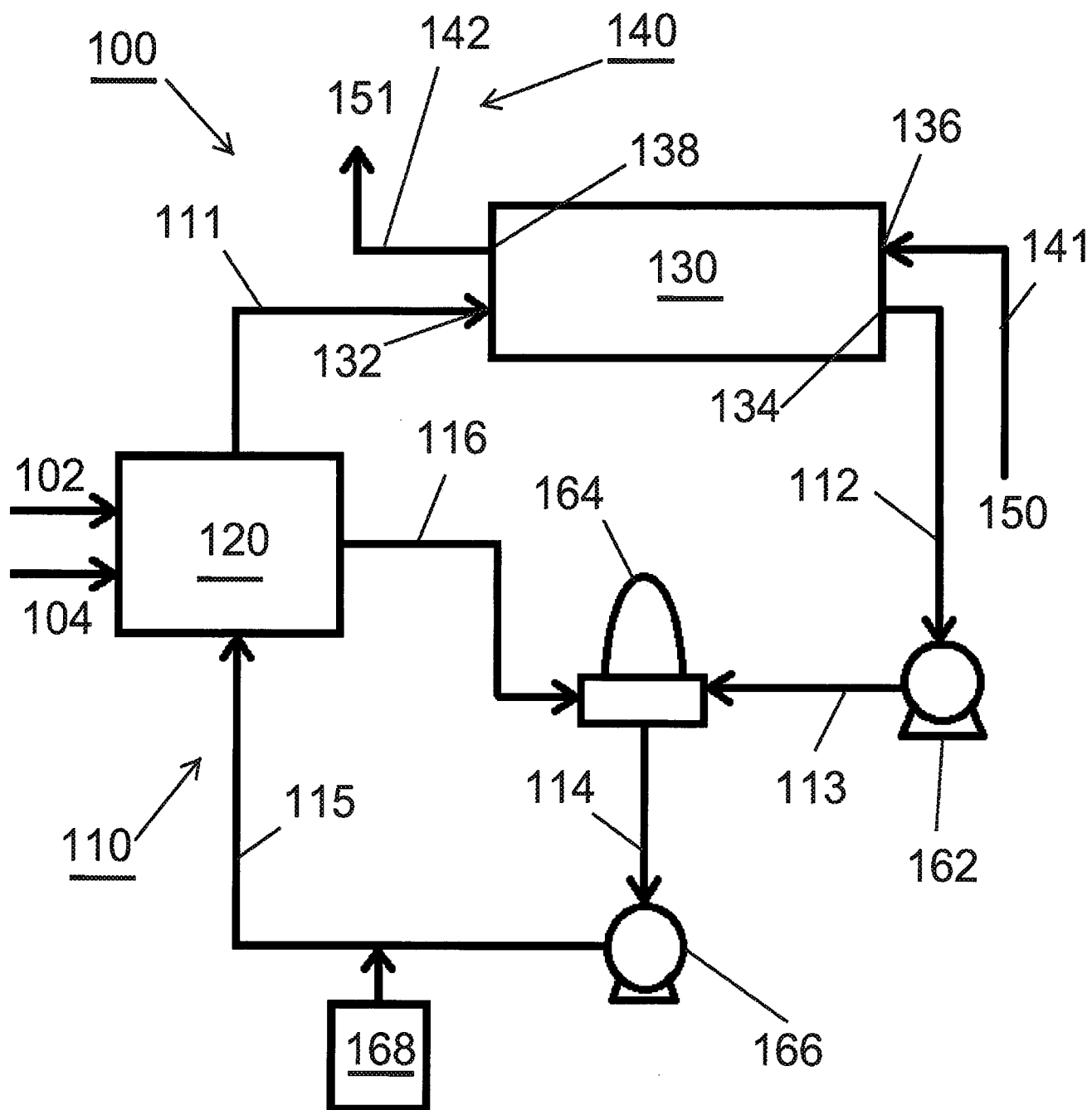


FIG. 1

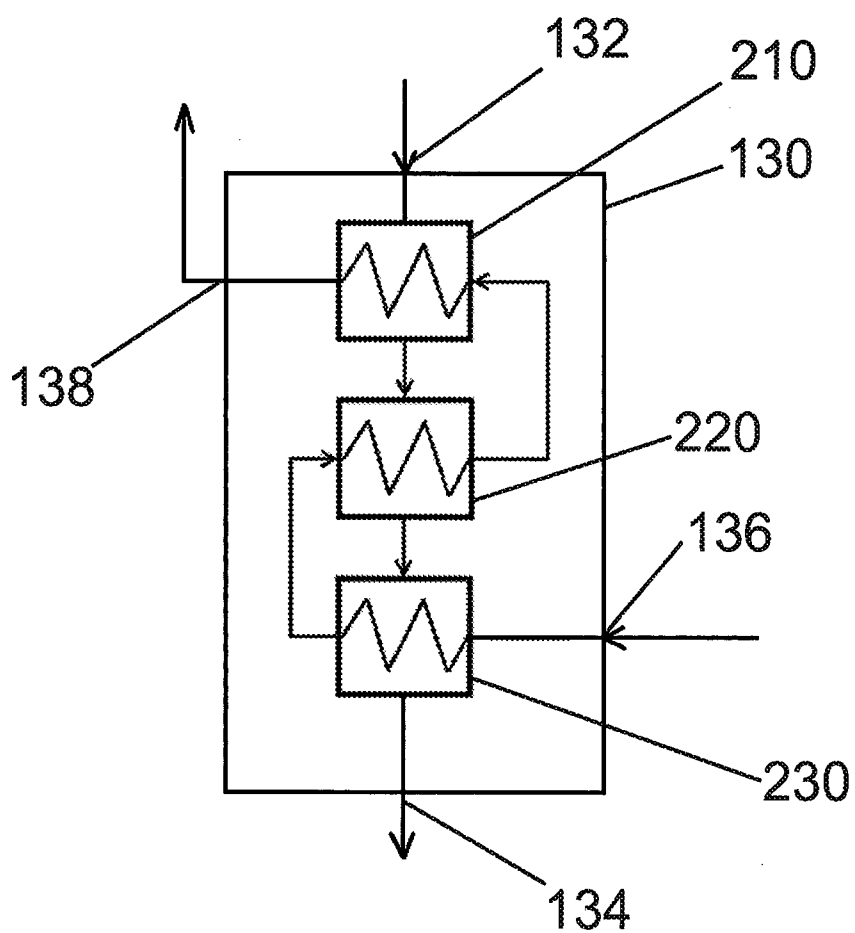


FIG. 2

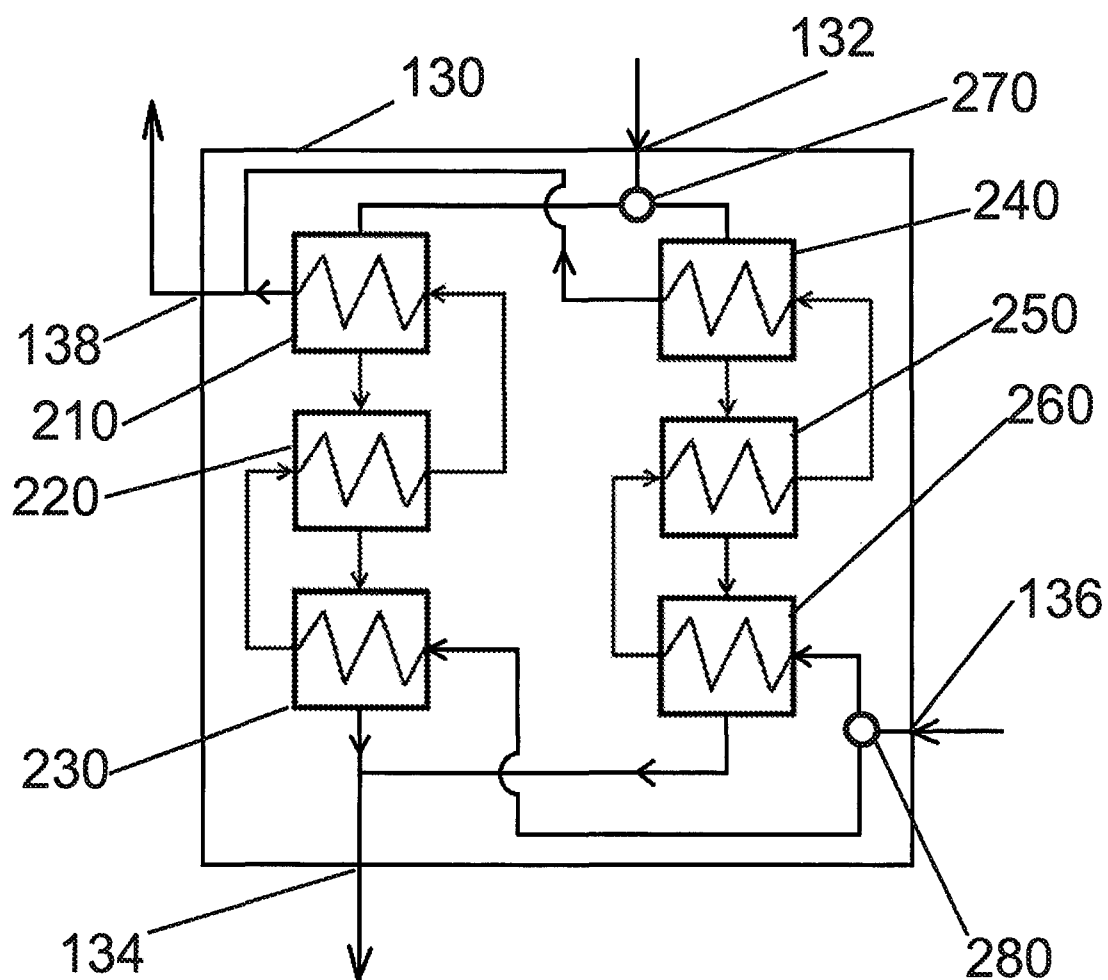


FIG. 3

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CESION

Yo, (nosotros) abajo firmado (s)

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domiciliado(s) en

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(3) 3945 Orangewood Way Uniontown, Ohio 44685, Estados Unidos de América

declaro(amos) bajo juramento ser único(s) y verdadero(s) inventor(es) de la invención:

SISTEMA PARA PRODUCIR VAPOR DE ALTA PRESIÓN DE AGUA DE BAJA CALIDAD

declaro(amos) así mismo que cedo(emos) y transfiero(erimos), sin limitación, a favor de la sociedad

BABCOCK & WILCOX POWER GENERATION GROUP, INC

constituída y existente de conformidad con las leyes de

domiciliada en

20 South Van Buren Avenue, Barberton, Ohio 44203-0351, Estados Unidos de América

todos los derechos inherentes a dicha invención y que la citada Compañía queda facultada para solicitar en su nombre la patente de invención correspondiente en la República de Colombia.

ASSIGNMENT

I (we), the undersigned

(1) RYAN, DONALD E

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state(s) under oath to be sole and true inventor(s) of the invention:

SYSTEM FOR PRODUCING HIGH PRESSURE STEAM FROM LOW QUALITY WATER

state as well, that assign, without reservations or limitations in favour of

BABCOCK & WILCOX POWER GENERATION GROUP, INC.

a corporation constituted and existing in conformity with the laws of

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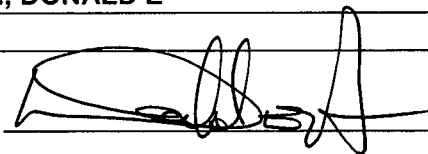
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all rights inherent to said invention and that the above mentioned company hereby is enabled to apply, in its name, for the corresponding patent invention, in the Republic of Colombia

Dado y firmado hoy/Given and signed this July 7, 2014
en/in _____

por/by RYAN, DONALD E

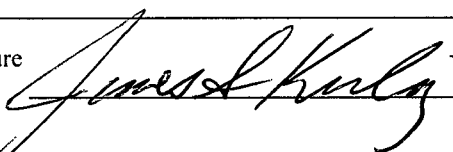
Firma/Signature



Dado y firmado hoy/Given and signed this July 1, 2014
en/in _____

por/by KULIG, JAMES S

Firma/Signature



Dado y firmado hoy/Given and signed this July 1, 2014
en/in _____

por/by PIERSON, LARRY A

Firma/Signature

