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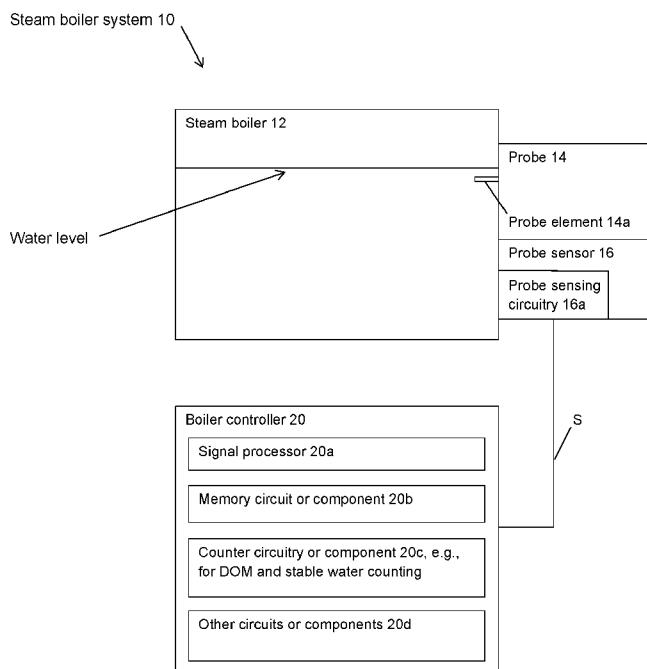


Figure 1: Steam Boiler System 10

(57) Abstract: A technique for determining a boiler water condition includes a boiler controller (aka PSE unit) having a signal processor that implements a boiler control algorithm to receive signaling containing information about sets of N consecutive probe data samples related to a boiler water condition; determine stable average signaling containing information about a stable average by averaging a set of N consecutive probe data samples in the signaling received; determine present stable average signaling containing information about a present stable average by averaging a present set of N consecutive probe data samples in the signaling received; and determine corresponding signaling containing information about the boiler water condition, based upon whether the present stable average is within an allowable limit and a comparison of the present and previous stable average signaling determined.



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SMART ALGORITHM TO DETERMINE "STEAM BOILER WATER CONDITION"**CROSS-REFERENCE TO RELATED APPLICATION**

This application claims benefit to provisional patent application serial no.

5 62/287,727, filed 27 January 2016, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION**1. Field of the Invention**

10 The present invention relates to a technique for determining a boiler water condition; and more particularly to a technique for monitoring and controlling a steam boiler water condition based upon the determination.

2. Brief Description of Related Art

15 The present PSE (Probe Steam Enhancement (aka "PS-Enhancement")) unit uses a model foam detection algorithm that averages water sample data over a period of time and compares each average sample data in an incremental manner with past sample data by a fixed constant. If this process is valid for four consecutive average data samples, then the system declares a foam condition in the
20 boiler. This averaging algorithm for foam detection starts as soon as the boiler unit is turned ON.

The present foam detection algorithm has a number of limitations/constraints that creates a faulty/irregular shutdown of boilers. By way of example, the limitations are as follows:

25 A. Probe resistance continuously varies inside the boiler due to the waves when the water starts boiling. By averaging the data, sometimes the

system satisfies the present foam condition algorithm and shuts down the boiler irregularly.

B. While feeding the cold water during a boiler out-of-water condition, the water resistance starts increasing (e.g., cold water has high resistance and hot water has low resistance). Change in water resistance will vary/increase the probe data. By averaging these incremental data samples, sometimes the system satisfies the present foam condition algorithm and shuts down the boiler irregularly.

C. When the water inside the boiler heats up, it will start to foam or create a bubble/foam. Checking water resistance in such a condition will give varying data samples. By averaging such varying data samples, sometimes the system satisfies the present foam condition algorithm and shuts down the boiler irregularly.

D. In small boilers, the water level goes down rapidly in comparison to large and medium sized boilers. In such cases, the probe resistance starts increasing due to the fast change in the water level. Such incremental change in water resistance sometimes satisfies the present foam condition algorithm and shuts down the boiler irregularly.

All above conditions create a faulty shutdown of boilers without any actual foam condition. To overcome such limitations, an algorithm has to be defined to measure water quality to calculate a foam threshold and start the foam condition algorithm when there is a continuous drop in water level. Change in water resistance is affected due to following parameters:

1. Size of Boiler – Large, Medium and Small size boilers;
2. Water Quality – Pure, with salt/conductive chemicals;

3. Hot or Cold water; and
4. Size of the water bubbles – When water heats-up.

In view of the aforementioned problems in the art, there is a need to provide a better way to detect and respond to such steam boiler water conditions.

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Detail Explanation of Each Point is Given Above

The following is a detailed explanation of each of the aforementioned points:

- A. Size of Boiler: Boilers are of a different size (Small, Medium and Large) depending upon the application. Change in the water level in a small sized boiler is typically much faster compared to a large sized boiler. If the foam algorithm starts reacting on the change in water level, then the system will encounter irregular tripping or boiler shutdown without a foam condition. To avoid such a condition, a water stability algorithm needs to be determined that takes this change in the water level into account.
- B. Water Quality: Need to start the foam condition once the probe data has crossed the fixed threshold. This will allow the foam algorithm to start once the probe data crosses the fixed threshold and allow the system to work on an actual foam condition. Water quality is an important parameter which varies depending upon the geographical location of the boiler and its application. By keeping a fixed foam threshold, the system will work for few applications (For example, for pure water applications for food processing, or for adding salt/chemicals for industrial applications) or some geographical locations but may not be true for all applications or locations. To cater to such conditions, the water quality check algorithm needs to be defined which will

check the water quality dynamically and adjusts the water threshold as per the application and geographical location.

C. Hot or Cold water: During the water feeding process, cold water will get added in existing hot water in the boiler. Since cold water resistance is higher than hot water resistance, this will increase the water resistance and allows the probe data to change. When the water level is low, the water feeder will start feeding cold water to the boiler, and it will get mixed with the existing hot water. The present foam algorithm will start reacting to the change in resistance from the first drop of cold water added to the boiler. This needs to be avoided, e.g., and may be resolved by allowing water to stabilize the boiler every time when the boiler trips.

D. Water bubble size: When water heats inside the boiler, water bubbles start to foam which is nothing but foam. These bubbles are of different size and of different resistance depend upon the water content. Such bubbles sensed by the probe will change the probe resistance and will cause or allow the present foam algorithm to start reacting without any consideration to the water level. Also the present foam algorithm is activated from the moment the boiler starts to operate. To solve this issue, an algorithm needs to be defined to check the drop in water level consecutively before starting the foam algorithm. This will make sure that the water level is below the probe.

SUMMARY OF THE INVENTION

In summary, the present invention takes into account both the aforementioned problems in the art and points recognized by the inventors, and provides a new and better way to detect and respond to such steam boiler water conditions.

5 By way of example, and according to some embodiments, the present invention takes the form of a new and unique boiler controller for determining a boiler water condition featuring a signal processor configured to implement a boiler control algorithm to:

10 receive signaling containing information about sets of N consecutive probe data samples related to the boiler water condition;

 determine stable average signaling containing information about a stable average by averaging a set of N consecutive probe data samples in the signaling received;

15 determine present stable average signaling containing information about a present stable average by averaging a present set of N consecutive probe data samples in the signaling received; and

20 determine corresponding signaling containing information about the boiler water condition, based upon whether the present stable average is within an allowable limit and a comparison of the present stable average signaling and the stable average signaling.

The boiler controller may also include one or more of the following features:

The signal processor may be configured to implement the boiler control algorithm to determine if the present stable average is within the allowable limit, then increment a stable water counter and rewrite the stable average signaling with the

present stable average signaling, else declare a foam condition as the boiler water condition and reset the stable water counter.

The signal processor may be configured to implement the boiler control algorithm to repeat for M sets of the N consecutive probe data samples the following:

- 5 determine if the present stable average is within the allowable limit based upon the comparison of the present stable average signaling and the stable average signaling; and
- if the present stable average is within the allowable limit, then increment the stable water counter and rewrite the stable average signaling
- 10 with the present stable average signaling, else declare a foam condition and resetting the stable water counter.

The signal processor may be configured to determine if any data sample is out of the allowable limits (+/-) while comparing present average and stable average, then the stable water counter will get reset and will start counting from 0.

- 15 The signal processor may be configured, once the stable water counter reaches to a count "M", to set a new foam threshold as a last average data + an offset.

The signal processor may be configured, once the water is stable, to sense the probe for consecutive probe data samples and verify if any crosses the foam

- 20 threshold before starting the foam algorithm and start a present foam algorithm only if this condition is satisfied.

According to some embodiments, the present invention may take the form of a method for determining the boiler water condition, featuring steps for:

- receiving in a signal processor signaling containing information about
- 25 sets of N consecutive probe data samples of the boiler water condition;

determining in the signal processor stable average signaling containing information about a stable average by averaging a set of N consecutive probe data samples in the signaling received;

determining in the signal processor present stable average signaling containing information about a present stable average by averaging a present set of N consecutive probe data samples in the signaling received; and

determining corresponding signaling containing information about the boiler water condition, based upon whether the present stable average is within an allowable limit and a comparison of the present stable average signaling and the stable average signaling.

The method may include, or take the form of, implementing the boiler control algorithm according to the present invention. The method may also include one or more steps for implementing one or more of the other features disclosed herein.

By way of example, advantage of the new boiler control algorithm may include:

1. A water stability check, e.g., that takes in account a change in the water level.

2. A water quality check, e.g., that checks and takes into account the water quality dynamically and adjusts the water threshold, e.g., as per the boiler application and geographical location.

3. A consecutive level water drop check, e.g., to check the drop in water level consecutively, e.g., before starting the foam algorithm.

BRIEF DESCRIPTION OF THE DRAWING

The drawing includes the following Figures, not necessarily drawn to scale, including:

Figure 1 is a block diagram of a boiler system, according to some embodiments of the present invention.

5 Figure 2 is a diagram of a flow chart for implementing steps A through H, according to some embodiments of the present invention.

In the Figures, similar parts are labeled with similar reference numerals. Moreover, not every part is labelled with a reference numeral and lead line in every Figure, so as to reduce clutter in the drawing.

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DETAILED DESCRIPTION OF THE INVENTION

Figure 1

By way of example, and according to some embodiments of the present invention, Figure 1 shows a steam boiler system generally indicated as 10 having a steam boiler 12 arranged or configured in relation to a probe 14 with a probe element 14a and a probe sensor 16 with probe sensing circuitry 16a, as well as a boiler controller 20 for implementing a boiler control algorithm for controlling the steam boiler 12. The boiler controller 20 may include, or form part of, a PSE unit, e.g., consistent with that set forth herein. By way of example, the boiler controller 20 may include a signal processor 20a arranged in relation to a memory circuit or component 20b and a counter circuit or component 20c for implementing DOM and stable water counting functionality. Associated signaling S may be exchanged between the boiler controller 20 and the probe sensing circuitry 16a, e.g., as shown in Figure 1. The boiler controller 20 may also include other circuits or components generally indicated as 20d, e.g., including input/output circuitry or components, data and control bus

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circuitry or components, as well as other circuitry or components to implement the signal processing functionality disclosed herein. Further, in the boiler controller 20 all of the circuits or components 20b, 20c, 20d are understood to be suitably coupled together for providing a suitable signaling exchange to/from the signal processor 20a
5 for implementing the signal processing functionality disclosed herein.

Algorithm To Overcome Prior Art Foam Algorithm Limitations:

The present invention takes into account and implements a new boiler control algorithm generally indicated as 30 in Figure 2 having steps A through H, which
10 includes a water stability check, a dynamic water quality check and a consecutive water level drop check, e.g., consistent with that set forth below:

A. Turn on the PSE unit.

Water Stability Check:

15 B. If the boiler's probe 14 is in an in-water condition, the boiler controller 20 in the steam boiler system will start a counter like counter 20c (see Fig. 1) for counting to a Delay on Make (DOM) count and will turn the boiler ON upon reaching the DOM count. By way of example, in operation the steam boiler system 10 may include the boiler controller 20 configured to implement the new boiler control algorithm to
20 receive probe sensing signaling containing information that the boiler's probe 14 is immersed in the boiler's water, and provide controller signaling to start the counter 20c to count to the DOM count. Upon reaching the DOM count, the boiler controller 20 will provide controller signaling to turn the steam boiler 12 ON. The DOM count is a counter or number, e.g. that is predetermined depending on the particular boiler

application and may be set in the boiler controller 20, e.g., as one skilled in the art would appreciate.

Dynamic Water Quality Check:

5 C. Once the steam boiler or burner 12 is ON, "N" consecutive probe data samples will be averaged and will be set as a stable average. By way of example, in operation the boiler controller 20 may be configured to implement the new boiler control algorithm to provide control signaling to actuate the probe sensor 16 and sense the probe 14, receive probe data signaling from the probe sensor 16
10 containing information about the "N" consecutive probe data samples, and provide further control signaling to store consecutive probe data signaling containing information about the "N" consecutive probe data sample, e.g., in the memory 20b (Fig. 1). Further, the boiler controller 20 may also be configured to receive memory signaling containing information about the "N" consecutive probe data samples (e.g.,
15 stored in the memory 20b (see Fig. 1)), process the memory signaling to determine stable average signaling containing information about the stable average, and store the stable average signaling in the memory 20b as a set stable average.

 D. Next "N" consecutive data samples will then be averaged and will be compared with the set "Stable average". If the present (i.e., next) stable average is
20 within an allowable limit(s) (or variation), then increment a stable water counter 20c and rewrite the stable average with the present stable average. By way of example, in operation the boiler controller 20 may be configured to implement the new boiler control algorithm, e.g., consistent with that set forth in step C, to sense the probe 14 and determine next "N" consecutive data sample signaling containing information
25 about the next "N" consecutive data samples, which may then be stored in memory

20b. Moreover, the boiler controller 20 may be configured to implement the new boiler control algorithm to provide control signaling to receive memory signaling containing information about the next "N" consecutive probe data samples (e.g., stored in a memory 20b), process the next "N" consecutive probe data samples to
5 obtain next stable average signaling containing information about the next stable average, compare the next stable average to the set stable average (e.g., stored and received back from in the memory 20b), and determine if the next stable average is within the allowable limit. If the boiler controller 20 determines that the next (i.e., present) stable average is within the allowable limit, then the boiler controller 20
10 provides control signaling to increment the counter 20c for stable water counting, rewrite the stable average signaling with the next stable average signaling, e.g., which may be stored in the memory 20b. The boiler controller 20 may also be configured to determine corresponding signaling containing information about the steam boiler water condition, e.g., based upon whether the present stable average is
15 within an allowable limit and a comparison of the present stable average signaling and the stable average signaling. The corresponding signaling may take the form of, or may include, control signaling to continue to implement the new boiler control algorithm to further monitor or evaluate the steam boiler water condition, e.g., including to shut down the boiler system consistent with that set forth herein. By way
20 of further example, the "allowable limit" may include, or take the form of, an allowable standard deviation, e.g., which may be determined depending on the boiler application. The scope of the invention is not intended to be limited to any particular allowable limit, e.g., small boiler applications may have one allowable limit, large boiler applications may have another allowable limit, and intermediate boiler

applications may have still another allowable limit, as one skilled in the art would appreciate.

E. The boiler controller 20 in the steam boiler system 10 may be configured to implement the new boiler control algorithm to repeat at least step D for “M” sets of
5 data samples.

F. If any data sample is out of the allowable limits (+/-) while comparing present average and stable average during the step D, then the stable water counter 20c will get reset and will start counting from 0. By way of example, in operation the boiler controller 20 may be configured to implement the new boiler control algorithm
10 to determine if any next (i.e., present) stable average is out of the allowable limits (+/-) while comparing the next stable average signaling and the set stable average signaling during the step D; and if so, then the boiler controller 20 may be configured to provide control signaling, e.g., to reset the stable water counter 20c to start counting from 0.

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Consecutive Water Level Drop Check:

G. Once the stable water counter 20c reaches to a count “M”, the last average data + an offset will be set as a new foam threshold. By way of example, in operation the boiler controller 20 may be configured to implement the new boiler
20 control algorithm to receive stable water counter signaling containing information that the stable water counter 20c reached the count “M”, and provide foam threshold signaling containing information about the last stable average data sample plus an offset to set as the foam threshold, e.g., which may be stored in the memory 20b. The scope of the invention is not intended to be limited to any particular so-called
25 offset, e.g., small boiler applications may have one offset. large boiler applications

may have another offset, and intermediate boiler applications may have still another offset, as one skilled in the art would appreciate. Moreover, the count M is a counter or number, e.g. that is predetermined depending on the particular boiler application and may be set in the boiler controller 20, e.g., as one skilled in the art would appreciate.

H. Once the water is stable, the probe 14 will sense, e.g., three consecutive probe data samples and verify if any crosses the foam threshold before starting the foam algorithm. The present foam algorithm will start only if this condition is satisfied. By way of example, in operation the boiler controller 20 may be configured to implement the new boiler control algorithm and provide control signaling to actuate the probe sensor 16 to sense the some consecutive number of probe data samples (e.g., 3), receive consecutive probe data sample signaling containing information about the consecutive probe data samples, process the consecutive probe data sample signaling, compare the consecutive probe data sample signaling to foam threshold signaling containing information about the foam threshold to verify if the consecutive probe data crosses the foam threshold, e.g., before starting the foam algorithm of the new boiler control algorithm. The scope of the invention is not intended to be limited to any particular so-called foam algorithm. The scope of the invention is intended to include, and embodiments are envisioned using, foam algorithms that are both now known in the art, and later developed in the future.

Table

The following is a table showing field validation reports:

Software - Field Validation Report

Sr. No	Client Name	Date	Part Number	Location	Customer Feedback
1	Client 1	Date 1	153827	Client 1 Address	Works well. NO issues found
2	Client 1	Date 1	153827	Client 1 Address	Works well. NO issues found
3	Client 2	Date 1	153827		Works well. NO issues found
4	Client 3	Date 2	153827		All Units are working good
5	Client 3	Date 2	153827		
6	Client 3	Date 2	153827		
7	Client 3	Date 2	153827		
8	Client 1	Date 3	153827	Client 1 Address	Works well. NO issues found
9	Client 3	Date 4	153927		All units are working good for client 3
10	Client 3	Date 4	153927		
11	Client 3	Date 4	153927		
12	Client 3	Date 4	153927		
13	Client 3	Date 4	153927		
14	Client 3	Date 4	153927		
15	Client 3	Date 4	153927		
16	Client 3	Date 4	153927		
17	Client 3	Date 4	153927		

The Scope of the Invention

It should be understood that, unless stated otherwise herein, any of the features, characteristics, alternatives or modifications described regarding a

- 5 particular embodiment herein may also be applied, used, or incorporated with any other embodiment described herein. Also, the drawing herein is not drawn to scale.

Although the invention has been described and illustrated with respect to exemplary embodiments thereof, the foregoing and various other additions and omissions may be made therein and thereto without departing from the spirit and scope of the present invention.

WHAT WE CLAIM IS:

1. A boiler controller for determining a boiler water condition comprising:

a signal processor configured to

receive signaling containing information about sets of N consecutive

5 probe data samples related to a boiler water condition;

determine stable average signaling containing information about a

stable average by averaging a set of N consecutive probe data samples in the
signaling received;

determine present stable average signaling containing information

10 about a present stable average by averaging a present set of N consecutive
probe data samples in the signaling received; and

determine corresponding signaling containing information about the

boiler water condition, based upon whether the present stable average is
within an allowable limit and a comparison of the present stable average

15 signaling and the stable average signaling.

2. A boiler controller according to claim 1, wherein the signal processor is also

configured to determine if the present stable average is within the allowable limit,

then increment a stable water counter and rewrite the stable average signaling with

20 the present stable average signaling, else declare a foam condition as the boiler
water condition and reset the stable water counter.

3. A boiler controller according to claim 2, wherein the signal processor is configured to repeat for M sets of the N consecutive probe data samples the following:

5 determine if the present stable average is within the allowable limit based upon the comparison of the present stable average signaling and the stable average signaling; and

 if the present stable average is within the allowable limit, then increment the stable water counter signaling and rewrite the stable average

10 signaling with the present stable average signaling, else declare a foam condition and resetting the stable water counter signaling.

4. A boiler controller according to claim 3, wherein the signal processor is configured to determine if any data sample is out of the allowable limits (+/-) while

15 comparing present average and stable average, then the stable water counter will get reset and will start counting from 0.

5. A boiler controller according to claim 4, wherein the signal processor is configured, once the stable water counter reaches to a count "M", to set a new foam

20 threshold as a last average data + an offset.

6. A boiler controller according to claim 5, wherein the signal processor is configured, once the water is stable, to sense the probe for consecutive probe data samples and verify if any crosses the foam threshold before starting the foam

25 algorithm and start a present foam algorithm only if this condition is satisfied.

7. A method for determining a boiler water condition comprising:

receiving in a signal processor signaling containing information about sets of N consecutive probe data samples related to a boiler water condition;

determining in the signal processor stable average signaling containing

5 information about a stable average by averaging a set of N consecutive probe data samples in the signaling received;

determining in the signal processor present stable average signaling containing information about a present stable average by averaging a present set of N consecutive probe data samples in the signaling received; and

10 determining corresponding signaling containing information about the boiler water condition, based upon whether the present stable average is within an allowable limit and a comparison of the present stable average signaling and the stable average signaling.

15 8. A method according to claim 7, wherein the method comprises, if the present stable average is within the allowable limit, then incrementing a stable water counter, and rewriting the stable average signaling with the present stable average signaling, else declaring a foam condition as the boiler water condition and resetting the stable water counter.

20 9. A method according to claim 8, wherein the method comprises repeating for M sets of the N consecutive probe data samples the steps of:

determining in the signal processor if the present stable average is within the allowable limit based upon the comparison of the present stable

25 average signaling and the stable average signaling; and

if the present stable average is within the allowable limit, then
incrementing with in the signal processor stable water counter signaling and
rewriting the stable average signaling with the present stable average
signaling, else declaring a foam condition and resetting the stable water
5 counter signaling.

10. A method according to claim 9, wherein the method comprises configuring
the signal processor to determine if any data sample is out of the allowable limits (+/-
) while comparing present average and stable average, then the stable water counter
10 will get reset and will start counting from 0.

11. A method according to claim 10, wherein the method comprises
configuring the signal processor, once the stable water counter reaches to a count
“M”, to set a new foam threshold as a last average data + an offset.

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12. A method according to claim 11, wherein the method comprises
configuring the signal processor, once the water is stable, to sense the probe for
consecutive probe data samples and verify if any crosses the foam threshold before
starting the foam algorithm and start a present foam algorithm only if this condition is
20 satisfied.

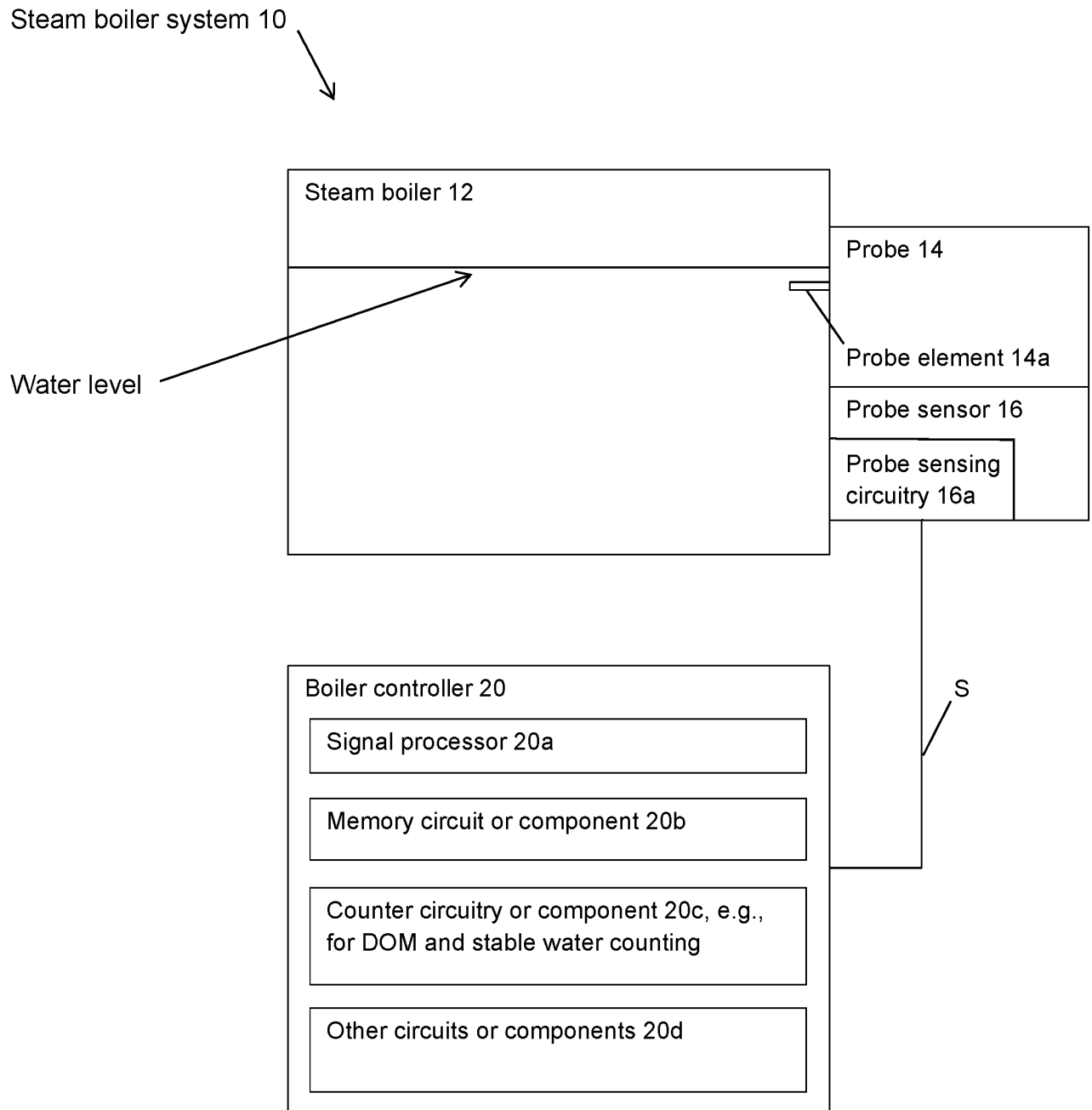


Figure 1: Steam Boiler System 10

Steam boiler control algorithm 30



A. Turn on the probe steam enhancement (PSE) unit (e.g., which may include, or take the form of, the boiler controller 20 (Fig. 1) for implementing the boiler control algorithm in Fig. 2)).

B. If the PSE unit senses and determines that the probe 14 is in an in-water condition, then the PSE unit starts a counter 20c for counting to DOM and turns the steam boiler 12 ON.

C. Once Boiler/Burner 12 is ON, the PSE unit takes and averages "N" consecutive probe data samples and sets a stable average, e.g., based upon the same.

D. The PSE unit takes and averages the next "N" consecutive data samples, determines a present sample average, and compares the present sample average with the "Stable average" determined in step C. If the present sample average determined in step D is within an allowable limit (+/-), then the PSE unit increments a stable water counter 20c and rewrites the stable average with the present sample average determined.

F. If the PSE unit determines that any data is out of the allowable limits (+/-) while comparing present average and stable average during the step D, then the PSE unit reset the stable water counter 20c, which will start counting from 0.

G. Once the stable water counter 20c reaches a count of "M", the PSE unit sets the foam threshold as the last average data sampled plus an offset.

H. Once the water is determined to be stable, the PSE unit uses the probe 14 and probe sensor 16 to sense, e.g., three consecutive probe data samples, and verifies if any of the consecutive probe data samples cross the foam threshold before starting the foam algorithm. The PSE unit starts the present foam algorithm only if this consecutive probe data sample condition is satisfied.

Figure 2: Boiler Control Algorithm 30

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 17/15268

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G01F 23/00 (2017.01)

CPC - G01F25/0061, G01F23/0061, G01F23/241

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2008/0109176 A1 (Merwin et al.), 08 May 2008 (08.05.2008), entire document, especially Abstract; Fig. 5; Para [0018], [0020], [0045], [0053]-[0054], [0068]	1 and 7 ----- 2-6 and 8-12
Y	US 2005/0043907 A1 (Eckel et al.), 24 February 2005 (24.02.2005), entire document, especially Abstract; Para [0267]-[0270]	2-6 and 8-12
A	US 2012/0010845 A1 (BOHAN et al.), 12 January 2012 (12.01.2012), entire document,	1-12
A	US 2013/0277440 A1 (COHEN), 24 October 2013 (24.10.2013), entire document,	1-12
A	WO 2011/131837 A1 (Foster Wheeler Energia Oy), 27 October 2011 (27.10.2011), entire document	1-12

☐ Further documents are listed in the continuation of Box C.

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"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
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