US 20230081044A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2023/0081044 A1

(43) Pub. Date: Mar. 16, 2023

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(54) METHOD AND SYSTEM FOR SERVICING A HEAT EXCHANGER

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(21) Appl. No.: **17/848,568**

(22) Filed: **Jun. 24, 2022**

(30) **Foreign Application Priority Data**

Sep. 16, 2021 (IN) 202141041977

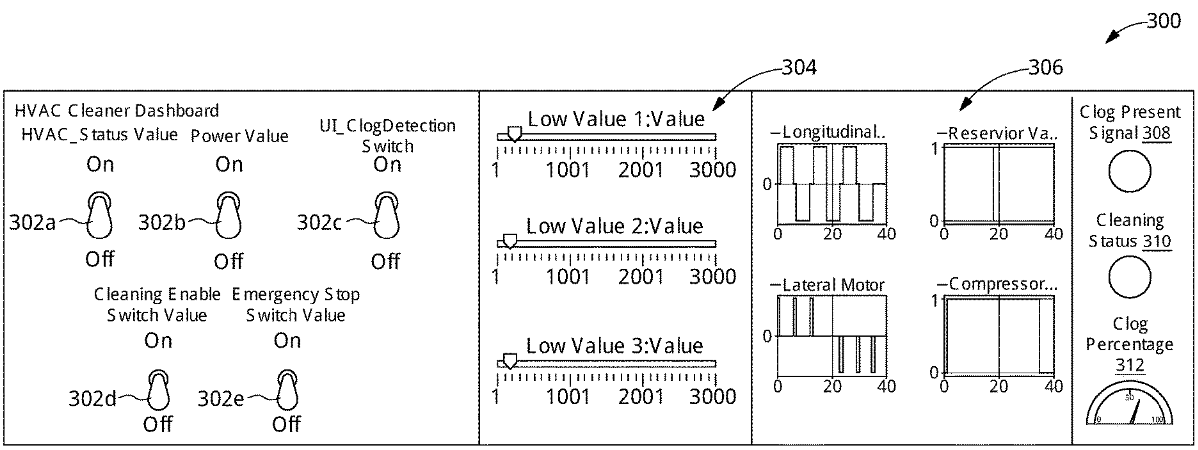
Publication Classification

(51) **Int. Cl.**
F28G 15/00 (2006.01)

(52) **U.S. Cl.**
CPC *F28G 15/003* (2013.01)

(57) **ABSTRACT**

A system (**100**) for servicing a heat exchanger is disclosed that includes a clog detection assembly (**108**) which further includes a light source (**110**) configured to be positioned on a first side of a component associated with the heat exchanger and illuminate the component. The clog detection assembly (**108**) further includes a light detector (**112**) configured to be positioned on a second side opposite the first side of the component to detect transmitted light and correspondingly generate a first signal. The system (**100**) further includes a processing device (**102**) communicatively coupled to the light detector (**112**). The processing device (**102**) analyzes the first signal to detect presence of a clog in association with the component. The processing device (**102**) may further cause a cleaning nozzle to move across the component, to perform a cleaning operation on the component.



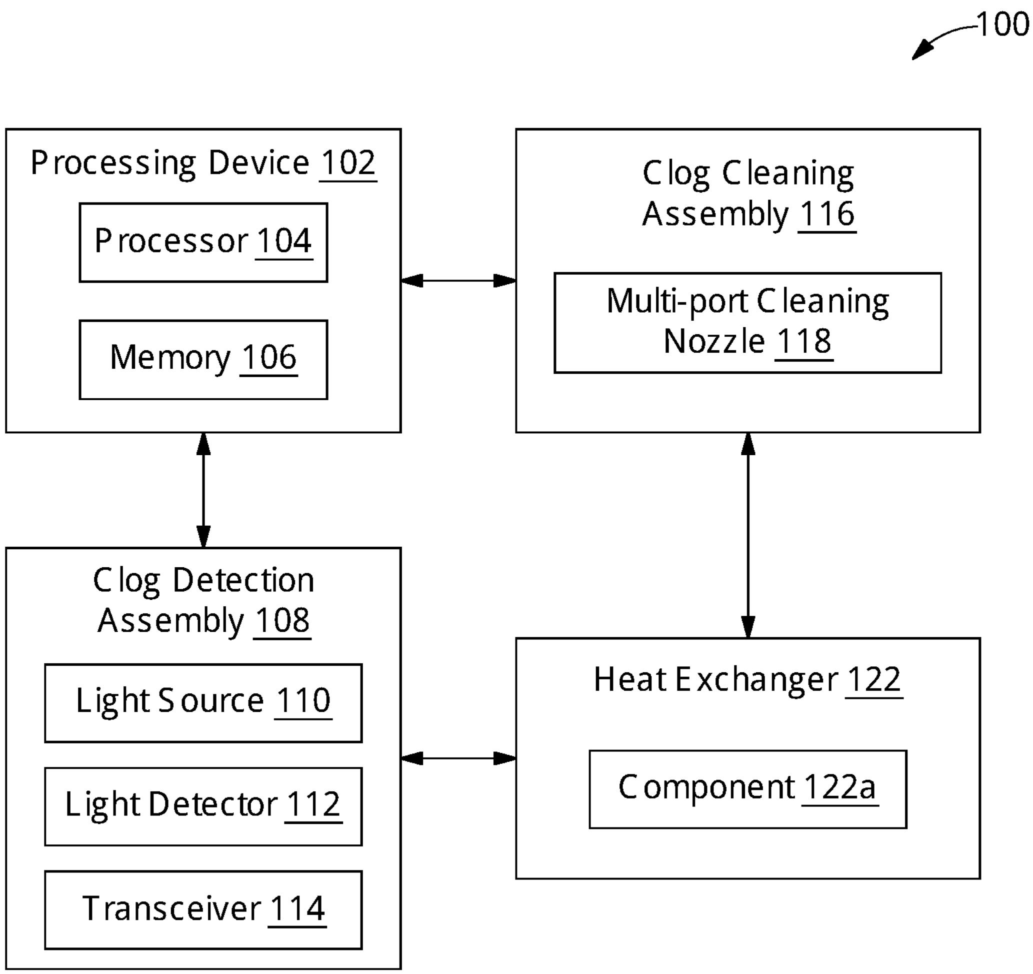

100
Processing Device 102
Processor 104
Memory 106
Clog Cleaning Assembly 116
Multi-port Cleaning Nozzle 118
Clog Detection Assembly 108
Light Source 110
Light Detector 112
Transceiver 114
Heat Exchanger 122
Component 122a

FIG. 1

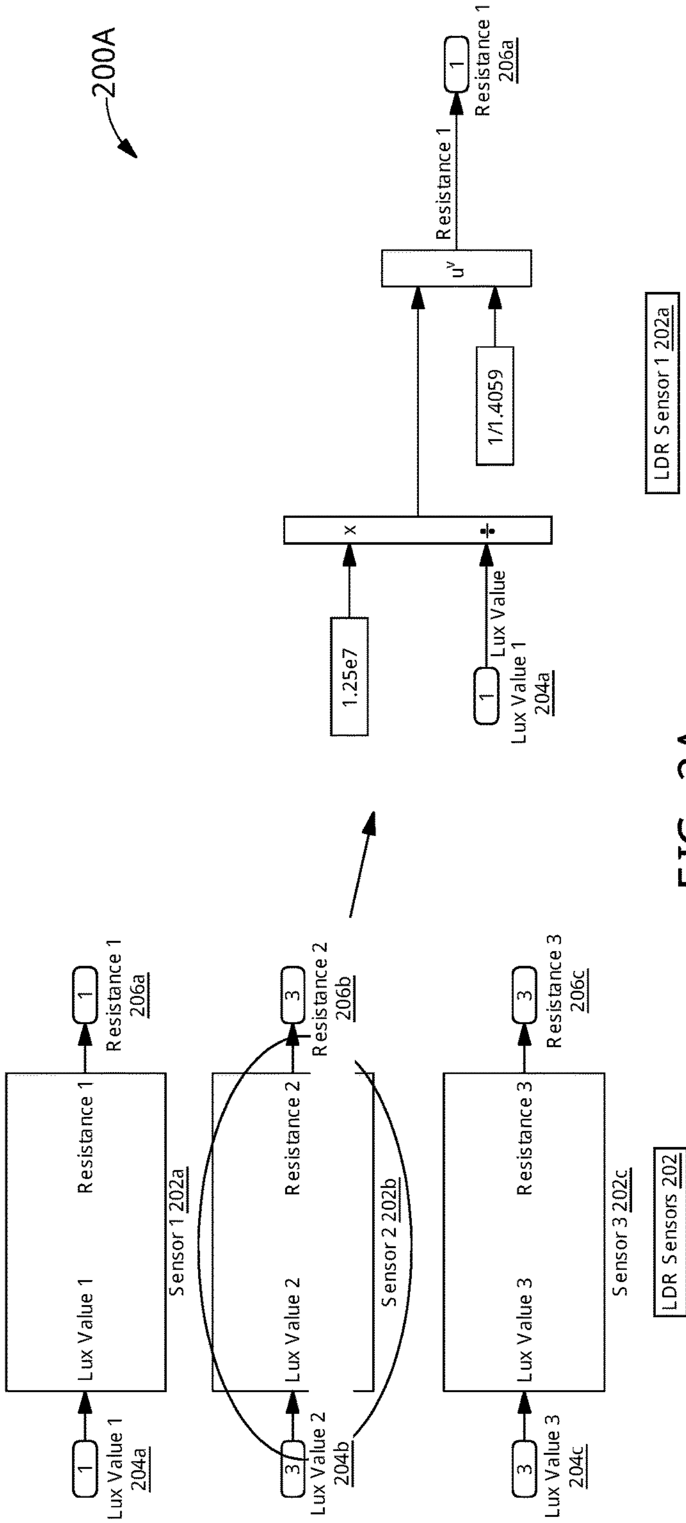
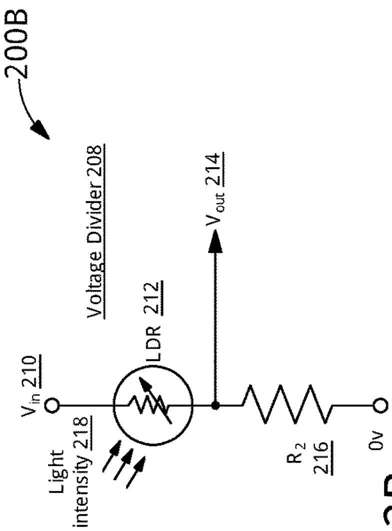


FIG. 2A



$$lux = (1.25 \times 10^7) \times R^{-1.4059}$$

FIG. 2B

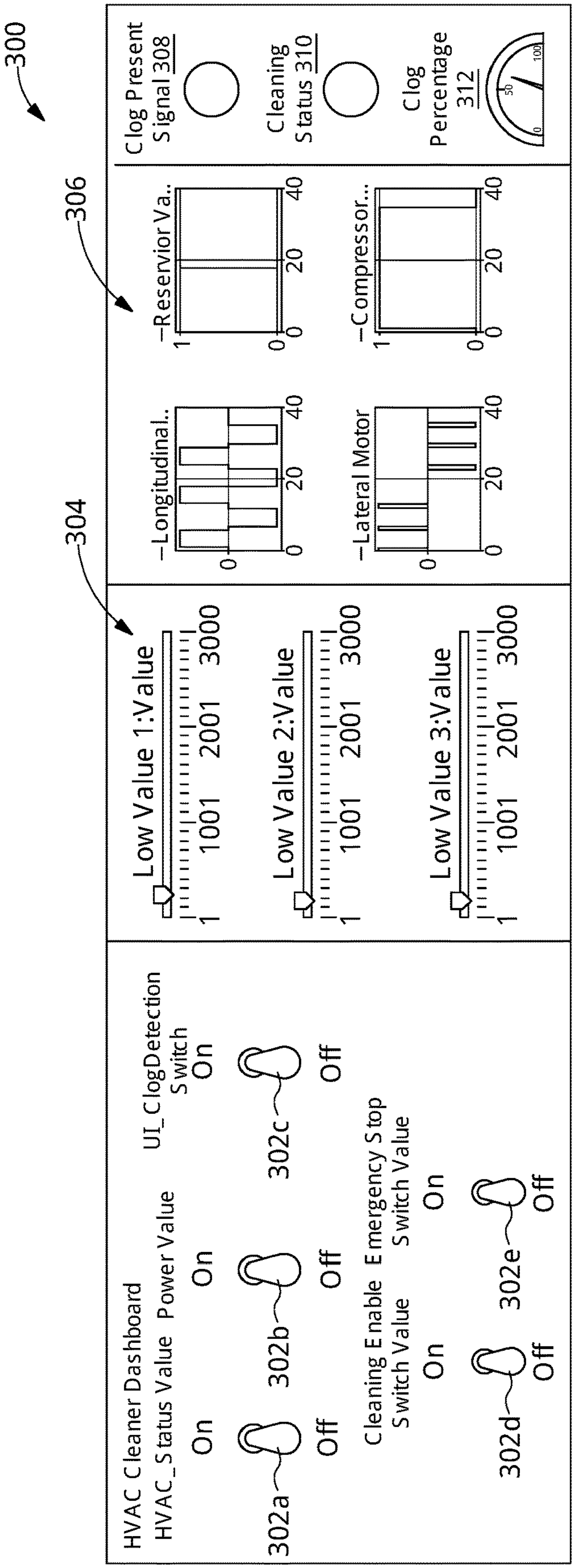
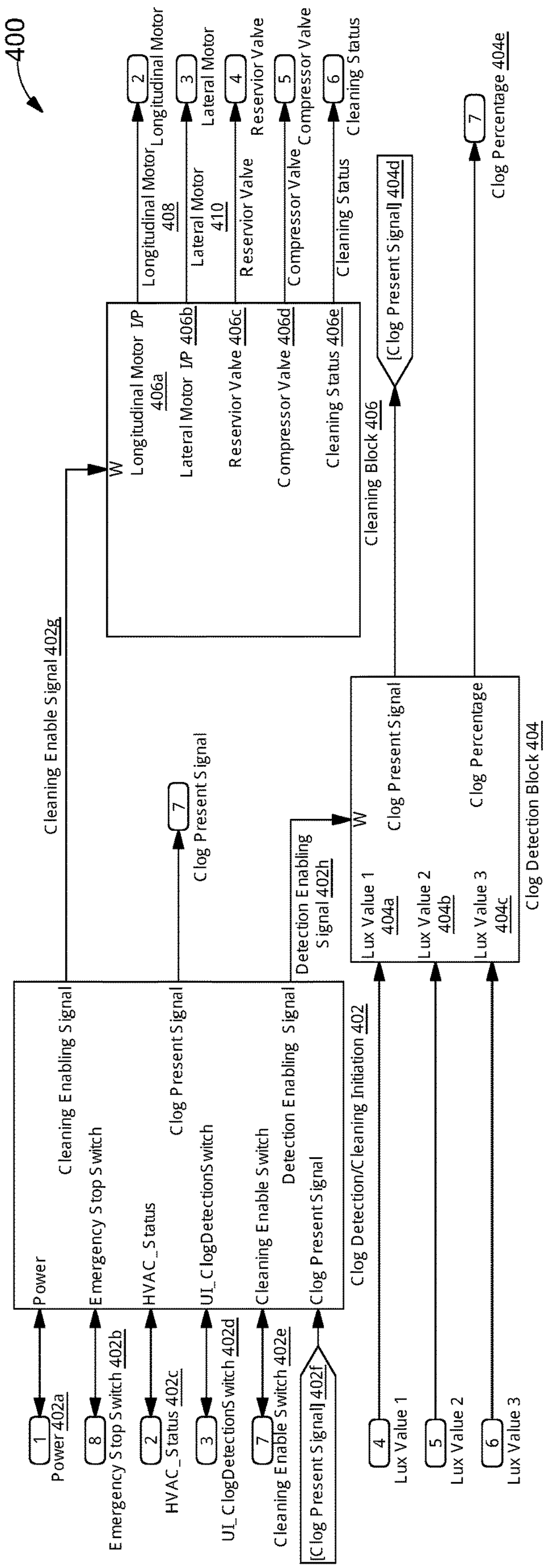

300
HVAC Cleaner Dashboard
HVAC_Status Value
Power Value
UI_ClogDetection Switch
On
Off
302a
302b
302c
Cleaning Enable Switch Value
Emergency Stop Switch Value
302d
302e
304
Low Value 1:Value
Low Value 2:Value
Low Value 3:Value
1
1001
2001
3000
306
Longitudinal..
Lateral Motor
Reservior Va..
Compressor...
0
20
40
1
Clog Present Signal 308
Cleaning Status 310
Clog Percentage 312
0
50
100

FIG. 3



400
Power 402a
Emergency Stop Switch 402b
HVAC_Status 402c
UI_ClogDetectionSwitch 402d
Cleaning Enable Switch 402e
[Clog Present Signal] 402f
Power
Emergency Stop Switch
HVAC_Status
UI_ClogDetectionSwitch
Cleaning Enable Switch
Clog Present Signal
Cleaning Enabling Signal
Clog Present Signal
Detection Enabling Signal
Clog Detection/Cleaning Initiation 402
Cleaning Enable Signal 402g
Clog Present Signal
Detection Enabling Signal 402h
Lux Value 1
Lux Value 2
Lux Value 3
Lux Value 1 404a
Lux Value 2 404b
Lux Value 3 404c
W
Clog Present Signal
Clog Percentage
Clog Detection Block 404
W
Longitudinal Motor I/P 406a
Lateral Motor I/P 406b
Reservior Valve 406c
Compressor Valve 406d
Cleaning Status 406e
Cleaning Block 406
[Clog Present Signal] 404d
Longitudinal Motor 408
Lateral Motor 410
Reservior Valve
Compressor Valve
Cleaning Status
Longitudinal Motor
Lateral Motor
Reservior Valve
Compressor Valve
Cleaning Status
Clog Percentage 404e
Clog Percentage

FIG. 4

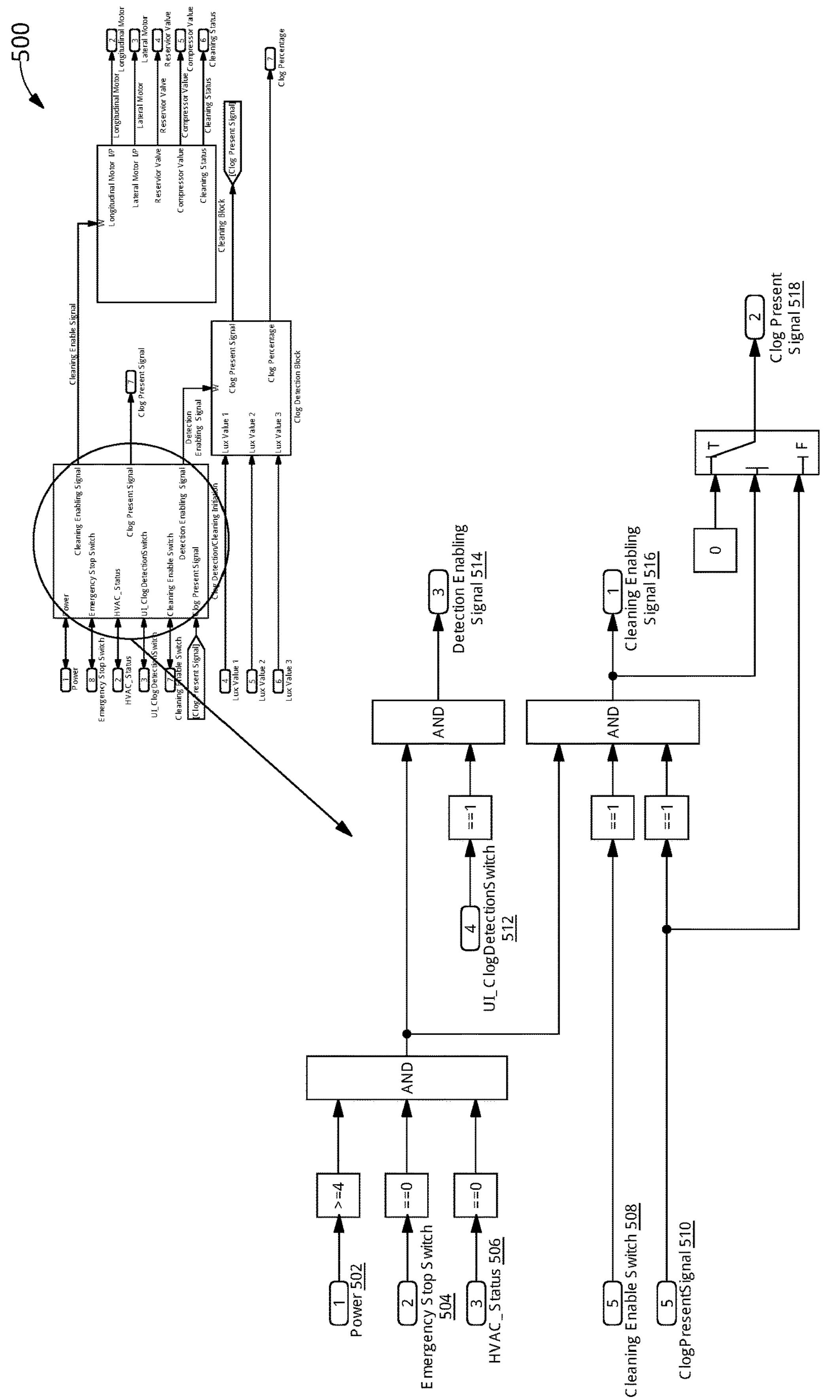
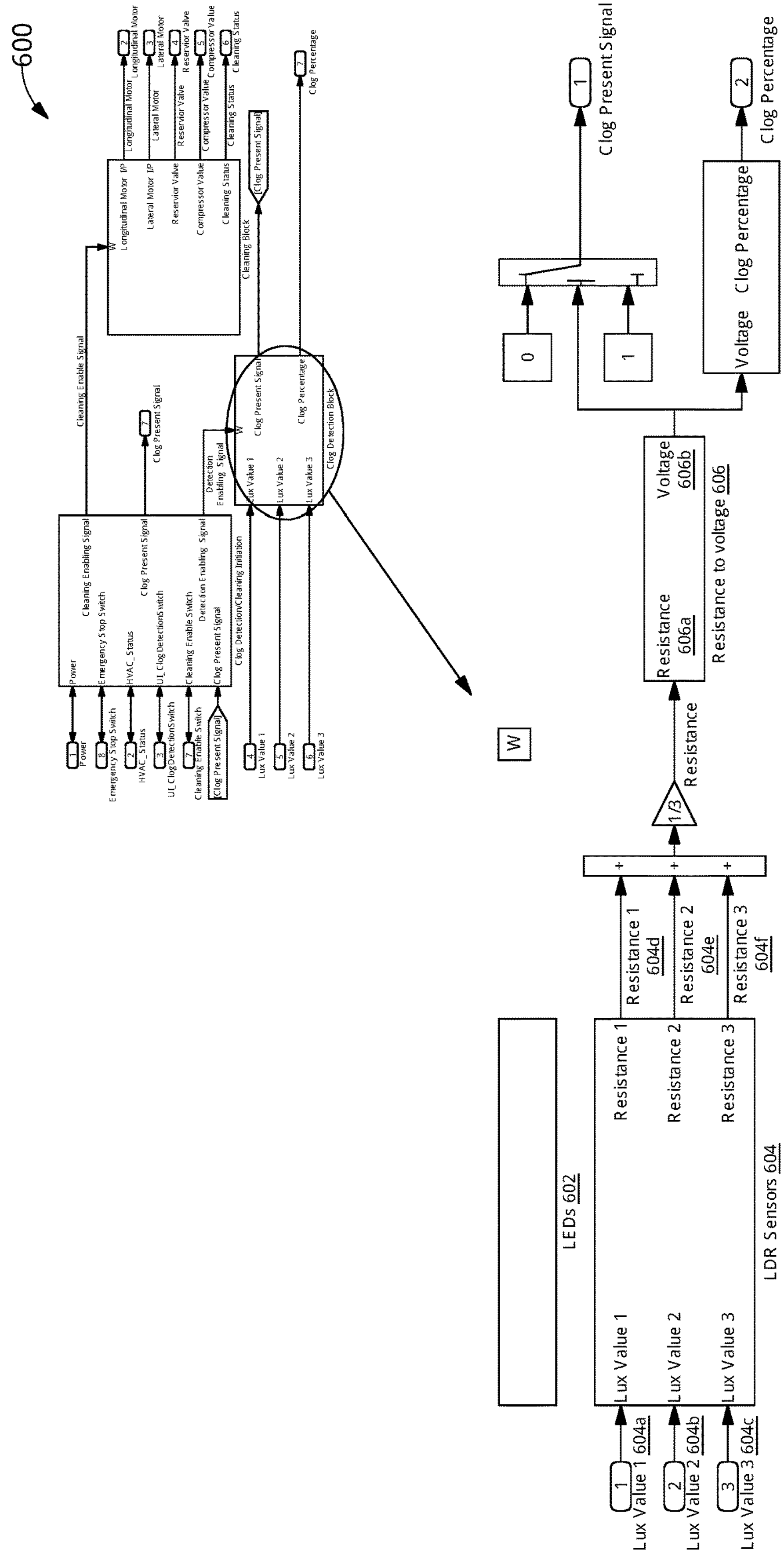

500
Power 502
Emergency Stop Switch 504
HVAC_Status 506
Cleaning Enable Switch 508
ClogPresentSignal 510
UI_ClogDetectionSwitch 512
Detection Enabling Signal 514
Cleaning Enabling Signal 516
Clog Present Signal 518
AND
>=4
==0
==1
T
F
Cleaning Block
Clog Detection Block

FIG. 5



600
Power
Emergency Stop Switch
HVAC_Status
UI_ClogDetectionSwitch
Cleaning Enable Switch
Clog Present Signal
Lux Value 1
Lux Value 2
Lux Value 3
Cleaning Enabling Signal
Detection Enabling Signal
Clog Detection/Cleaning Initiation
Cleaning Enable Signal
Longitudinal Motor
Lateral Motor
Reservior Valve
Compressor Value
Cleaning Status
Cleaning Block
Clog Percentage
Clog Detection Block
W
LEDs 602
Lux Value 1 604a
Lux Value 2 604b
Lux Value 3 604c
Resistance 1
Resistance 2
Resistance 3
LDR Sensors 604
Resistance 1 604d
Resistance 2 604e
Resistance 3 604f
1/3
Resistance
Resistance 606a
Voltage 606b
Resistance to voltage 606
0
1
Clog Present Signal
Voltage
Clog Percentage

FIG. 6

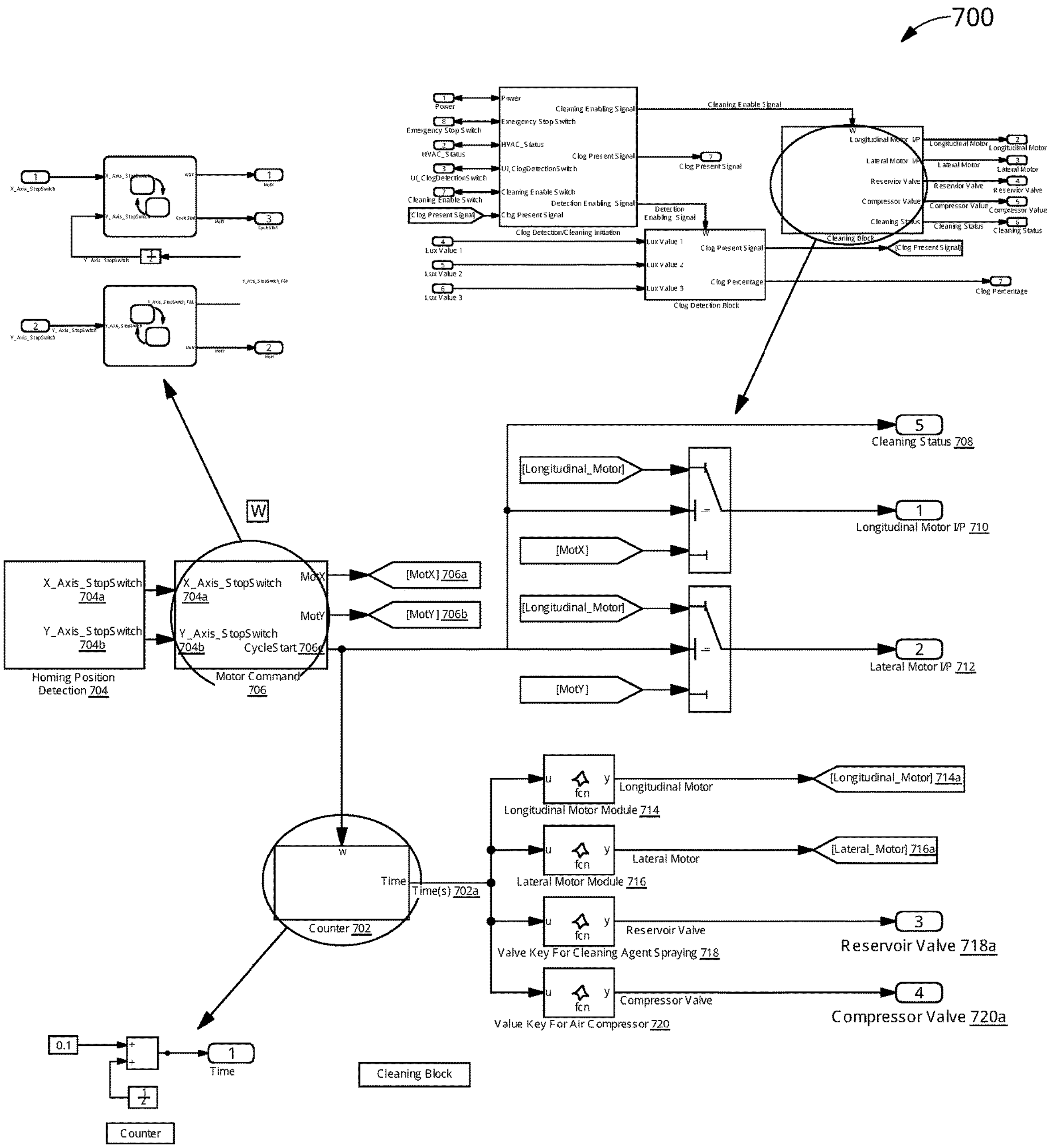

700
Cleaning Enable Signal
Clog Present Signal
Clog Detection/Cleaning Initiation
Clog Detection Block
Cleaning Block
Clog Percentage
W
5
Cleaning Status 708
[Longitudinal_Motor]
1
Longitudinal Motor I/P 710
[MotX]
[Longitudinal_Motor]
2
Lateral Motor I/P 712
[MotY]
X_Axis_StopSwitch
704a
Y_Axis_StopSwitch
704b
Homing Position
Detection 704
X_Axis_StopSwitch
704a
MotX
MotY
Y_Axis_StopSwitch
704b
CycleStart 706c
Motor Command
706
[MotX] 706a
[MotY] 706b
u
y
fcn
Longitudinal Motor
Longitudinal Motor Module 714
[Longitudinal_Motor] 714a
Lateral Motor
Lateral Motor Module 716
[Lateral_Motor] 716a
W
Time
Time(s) 702a
Counter 702
Reservoir Valve
Valve Key For Cleaning Agent Spraying 718
3
Reservoir Valve 718a
Compressor Valve
Value Key For Air Compressor 720
4
Compressor Valve 720a
0.1
1
Time
Cleaning Block
Counter

FIG. 7

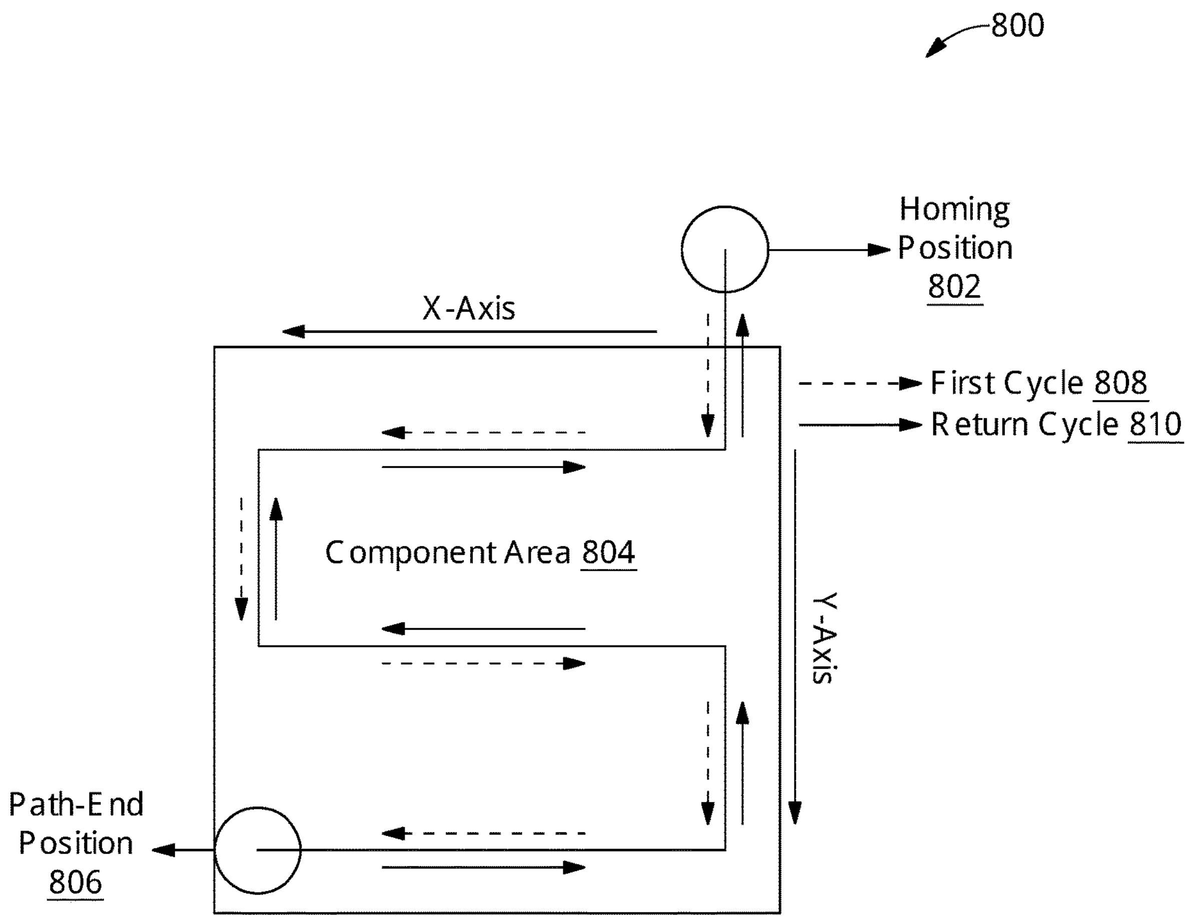

800
Homing Position 802
X-Axis
First Cycle 808
Return Cycle 810
Component Area 804
Y-Axis
Path-End Position 806

FIG. 8

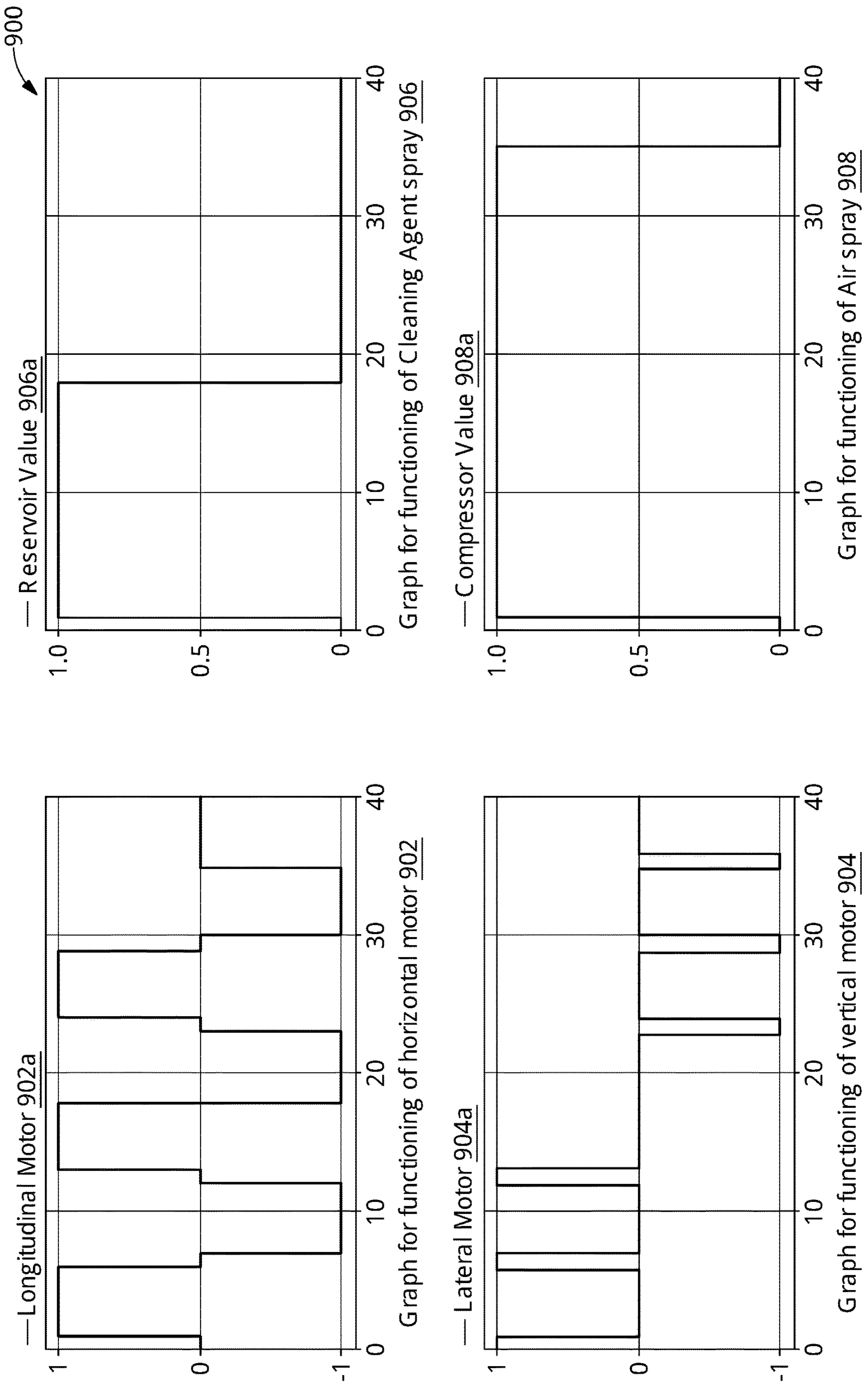

900
Longitudinal Motor 902a
Graph for functioning of horizontal motor 902
Lateral Motor 904a
Graph for functioning of vertical motor 904
Reservoir Value 906a
Graph for functioning of Cleaning Agent spray 906
Compressor Value 908a
Graph for functioning of Air spray 908
1
0
-1
1.0
0.5
0
0
10
20
30
40

FIG. 9

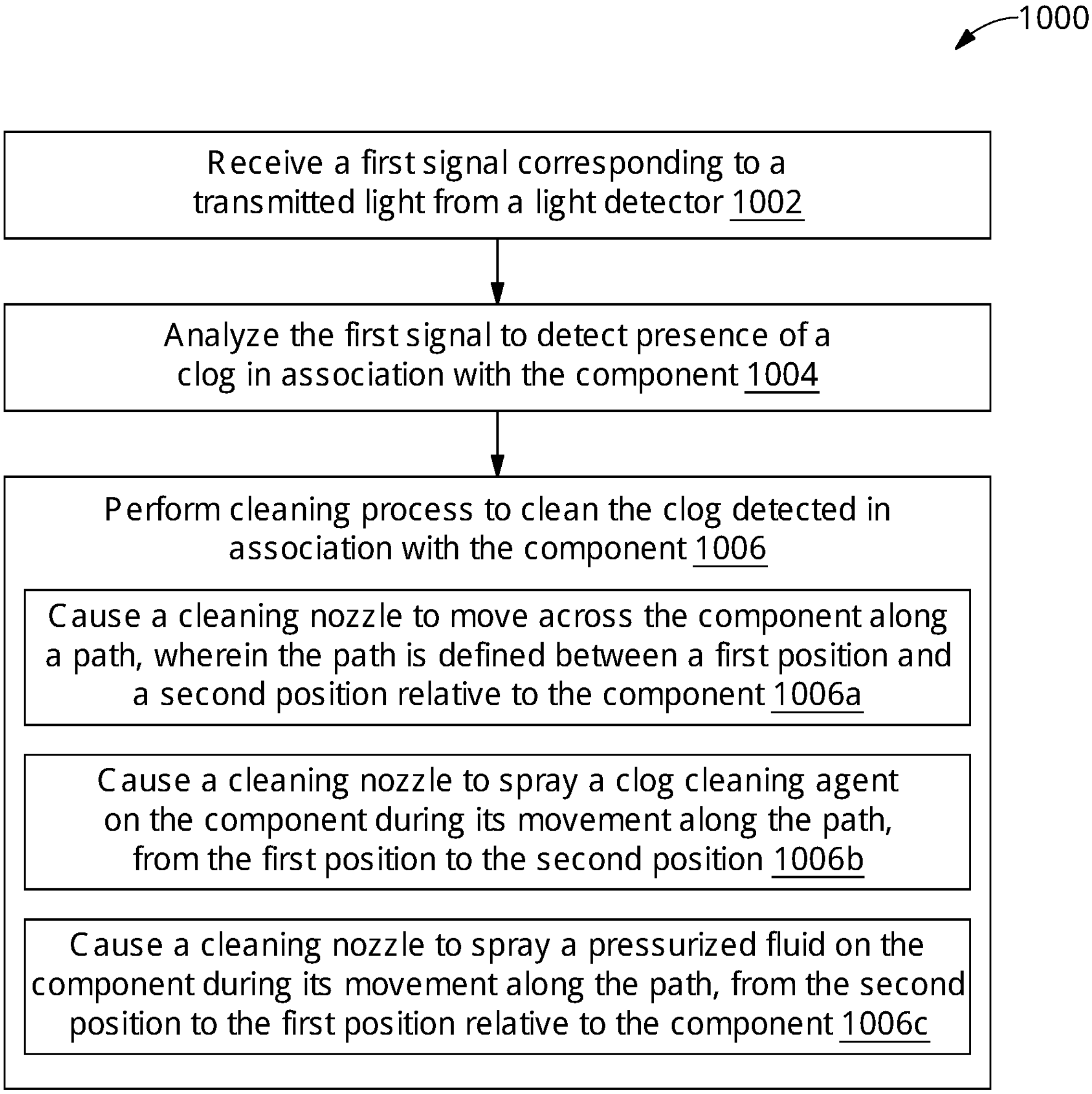

1000
Receive a first signal corresponding to a transmitted light from a light detector 1002
Analyze the first signal to detect presence of a clog in association with the component 1004
Perform cleaning process to clean the clog detected in association with the component 1006
Cause a cleaning nozzle to move across the component along a path, wherein the path is defined between a first position and a second position relative to the component 1006a
Cause a cleaning nozzle to spray a clog cleaning agent on the component during its movement along the path, from the first position to the second position 1006b
Cause a cleaning nozzle to spray a pressurized fluid on the component during its movement along the path, from the second position to the first position relative to the component 1006c

FIG. 10

METHOD AND SYSTEM FOR SERVICING A HEAT EXCHANGER

TECHNICAL FIELD

[0001] This disclosure relates generally to heat exchangers, and more particularly to a system and method for servicing a heat exchanger by detecting a clog in a heat exchanger component and cleaning the heat exchanger component.

BACKGROUND

[0002] A heat exchanger component (for example, a Heating Ventilation, and Air-Conditioning (HVAC) coil) installed in the heat exchanger may get clogged with dust and suspended particles in the air on an air side of the coil when exposed to air. Clogging may lead to reduced performance of a heat exchanger system and malfunctioning of the heat exchanger system further leading to complete failure.

[0003] Therefore, for minimizing an impact of the clogging, coils are required to be cleaned regularly or whenever the coil gets clogged. However, manual cleaning and maintenance of the coils may require large amount of time and effort. Additionally, concept of periodic cleaning of the coils at regular intervals may not be an optimum way of cleaning, as the clogging of the coils depends on varied environmental conditions in which the heat exchanger is being operated.

[0004] There is therefore a need in the art to provide a compact, an economically viable and effective automatic/semi-automatic system capable of detecting an extent of clogging on the coils, and the cleaning the coil in a minimal time span.

SUMMARY OF THE INVENTION

[0005] In an embodiment, a system for servicing a heat exchanger is disclosed. The system may include a clog detection assembly. The clog detection assembly may include a light source configured to be positioned on a first side of a component associated with the heat exchanger and further configured to illuminate the component with a projected light beam. The clog detection assembly may further include a light detector configured to be positioned on a second side opposite the first side of the heat exchanger component and further configured to detect transmitted light, in response to the projected light beam transmitting through the component, to generate a first signal corresponding to the transmitted light. The system may further include a processing device communicatively coupled to the light detector. The processing device may further include a processor and a memory configured to store processor executable instructions, which, on execution, may cause the processor to receive a first signal corresponding to the transmitted light from the light detector. The processor-executable instructions, on execution, may further cause the processor to analyze the first signal to detect presence of a clog in association with the component

[0006] In another embodiment a method of servicing a heat exchanger is disclosed. The method may include receiving a first signal corresponding to a transmitted light from a light detector. The light detector may be positioned on a second side of a component associated with the heat exchanger. Further, the light detector may be configured to detect transmitted light in response to a projected light beam projected by a light source and transmitting through the component to generate the first signal corresponding to the transmitted light. It should be noted that the light source may be positioned on a first side of the component opposite to the second side. The method may further include analyzing the first signal to detect presence of a clog in association with the component. The method may further include moving the cleaning nozzle across the component along a path upon detecting presence of the clog in association with the component. It should be noted that the path may be defined between a first position and a second position relative to the component. The method may further include causing the cleaning nozzle to spray a clog cleaning agent on the component during its movement along the path, from the first position (also referred to as homing position in this disclosure) to the second position (also referred to as path end position in this disclosure). The method may further include causing the cleaning nozzle to spray a pressurized fluid on the component during its movement along the path, from the second position to the first position relative to the component.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles.

[0008] FIG. **1** illustrates a block diagram of a system for servicing a heat exchanger, in accordance with an embodiment of the present disclosure.

[0009] FIG. **2**A illustrates a block diagram of a system representing a clog detection assembly including Light Dependent Resistors (LDRs) for detecting a clog present in a component association with a heat exchanger, in accordance with an embodiment of the present disclosure.

[0010] FIG. **2**B illustrates a schematic diagram of a system for conversion of luminance to resistance and conversion of resistance to voltage, in accordance with an embodiment of the present disclosure.

[0011] FIG. **3** illustrates a dashboard of a system for detecting a clog and cleaning the clog, in accordance with an embodiment of the present disclosure.

[0012] FIG. **4** illustrates a framework of a system for detecting a clog and cleaning the clog, in accordance with an embodiment of the present disclosure.

[0013] FIG. **5** illustrates a schematic circuit diagram of a sub-system of the system of FIG. **4** for triggering detection of a clog, in accordance with an embodiment of the present disclosure.

[0014] FIG. **6** illustrates a schematic circuit diagram of a sub-system of the system of FIG. **4** for detecting the clog, in accordance with an embodiment of the present disclosure.

[0015] FIG. **7** illustrates a schematic circuit diagram of a sub-system of the system of FIG. **4** for cleaning the clog, in accordance with an embodiment of the present disclosure.

[0016] FIG. **8** illustrates a path of movement followed by a cleaning nozzle for cleaning a clog present in association with a component associated with a heat exchanger, in accordance with an embodiment of the present disclosure.

[0017] FIG. **9** illustrates graphical representations of movement of a cleaning nozzle, in accordance with an embodiment of the present disclosure.

[0018] FIG. **10** illustrates a flow chart of a method for servicing a heat exchanger, in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE DRAWINGS

[0019] Exemplary embodiments are described with reference to the accompanying drawings. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the spirit and scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope and spirit being indicated by the following claims. Additional illustrative embodiments are listed below.

[0020] The disclosure pertains to detection of a clogging condition in heat exchanger components using a light source and a light detector (for example, a photodiode). For example, a heat exchanger component may be a Heating, Ventilation, and Air Conditioning (HVAC) coil. As light falls on the light detector or the photodiode, a voltage divider circuit may generate a voltage that may be proportional to amount of light intensity of the light source. Further, a decreasing light intensity may increase resistance in Light Dependent Resistors (LDR). Resistance is inversely proportional to the voltage, and thus when light is blocked on the LDR by dust or debris, less voltage may be obtained. A threshold value (for received light) may be defined as conditions indicating the presence of clog. When there is less voltage value than the threshold value of light intensity, it may indicate that the component may be clogged. This indication may be sent to and displayed on a dashboard or any handheld device to intimate a user about the clogging, so that cleaning process may be initiated. Examples of the handheld device may include, but are not limited to, iPads and laptops).

[0021] In an embodiment, cleaning of the clog may be performed in two steps. In a first step, a spray clog cleaning agent may be used and in a second step, an air pressure may be used to remove debris from the clog. The steps may be performed by using a cleaning nozzle which may move along a predefined path controlled by a micro controller. Further, an air compressor or blower may supply pressurized air to the cleaning nozzle via a multiport valve which may be controlled by the micro controller. The multiport valve may be opened by the micro controller when a clog cleaning agent is to be sprayed for cleaning. Thus, one pipe may account for both delivery of gaseous fluid and cleaning agent. After cleaning, the clog debris along with the cleaning agent may be drained through a drainpipe.

[0022] Referring now to FIG. **1**, a block diagram of a system **100** for servicing a heat exchanger **122** is illustrated, in accordance with an embodiment. The system **100** may be controlled via a control box hardware or even remotely using a phone, a laptop, and the like. The system **100** includes a processing device **102**, a clog detection assembly **108**, and a clog cleaning assembly **116**. The processing device **102** may further include a processor **104** and a memory **106**. The processing device **102** may process instructions to various modules **108-118** of the system **100**.

[0023] Further, the clog detection assembly **108** may include a light source **110**, a light detector **112**, and a transceiver **114**. The light source **110** may be configured to be positioned on a first side of a component **122*a*** associated with the heat exchanger **122** and further configured to illuminate the component **122*a*** with a projected light beam. It should be noted that the component **122*a*** may be a coil fin structure. The light detector **112** may be configured to be positioned on a second side opposite to the first side of the component **122*a*** and further configured to detect transmitted light, in response to the projected light beam transmitting through the component **122*a***, to generate a first signal corresponding to the transmitted light. Examples of light detector **112** may include but are not limited to a photodiode, a LDR, a phototransistor or any photovoltaic devices. The transceiver **114** may be used to transmit and receive signals to and from the processing device **102**. The clog detection assembly **108** may be operatively coupled to the clog cleaning assembly **116** via the processing device **102** and the heat exchanger **122**.

[0024] The processing device **102** may be communicatively coupled to the light detector **112** of the clog detection assembly **108**. The processor **104** may receive a signal transmitted from the light detector **112** via the transceiver **114** and further processes the signals as executable instructions to be followed by the clog cleaning assembly **116** upon detection of the clog. Examples of the processor **104** may include, but are not limited to, a microprocessor, a microcontroller, or a control logic. The memory **106** may be communicatively coupled to the processor **104** and store processor executable instructions. The processor executable instructions upon execution by the processor **104** may cause the processor **104** to receive a first signal corresponding to a transmitted light from the light detector **112** and analyze the first signal to detect presence of a clog in association with a component **122*a***.

[0025] Further, the processing device **102** may interact with a clog cleaning assembly **116**. The clog cleaning assembly **116** may further include a multi-port cleaning nozzle **118** and may optionally include a transceiver. In some embodiments, the multiport cleaning nozzle may be referred as a cleaning nozzle. The multiport cleaning nozzle may include a multiport valve, through which a user can choose between a clog cleaning agent (i.e. cleaning fluid) and pressurized air. The clog cleaning agent may be retrieved from a cleaning agent reservoir, and the pressurized air may be obtained from a pressurized air source. The multiport cleaning nozzle may include a nozzle that may spray the fluid chose through the multiport valve, via a controller. It should be noted that the clog detection assembly **108**, upon detection of a minimum clog threshold value (i.e. minimum voltage and maximum clog), may send information to the processing device **102**. The processing device **102** further processes the information to the clog cleaning assembly **116**. The clog cleaning assembly **116** may be configured to initiate a cleaning process. The multiport cleaning nozzle **118** upon receiving the processor executable instructions may move across the component **122*a*** across a path. Further, the multiport cleaning nozzle **118** may spray a clog cleaning agent on the component **122*a*** during its movement along the path, from a first position to a second position relative to the component **122*a***. Moreover, the multiport cleaning nozzle **118** may spray a pressurized fluid on the component **122*a*** during its movement along the path, from the second position to the first position relative to the component **122*a***. The transceiver of the clog cleaning assembly **116** may be used to receive and send signals to the processing device **102**.

[0026] It should be noted that the path may be a predefined a path. The path may be defined between a first position (For example, a homing position) and a second position (loop end position) relative to the component **122***a*. Also, it should be noted that the path may be generated in real time based on an analysis of the coil area.

[0027] Further, upon receiving the processor executable instruction, the processor **104** may first obtain a current position of the cleaning nozzle. In some embodiments, the processor **104** may cause the cleaning nozzle **118** to return to the first position, by moving along a reset path. The reset path may help in protecting the system **100** during a sudden power failure/power off/emergency stop condition. The reset path may be generated based on a predefined criterion. The predefined criteria may be selected from a set of predefined criteria. In some embodiments, the predefined criteria may be a first predefined criteria which may be based on a shortest path between the current position and the first position. Thus, in case of sudden failure, the cleaning nozzle may quickly reach the homing position. Further, in some embodiments, the predefined criteria may be a second predefined criteria which may be based on a quickest travel path between the current position and the first position. In some embodiments, the predefined criteria may be a third predefined criteria, which may be based on a least operation time of one or more motors configured to cause the cleaning assembly **116** move between the current position and the first position. In some other embodiments the processor **104** may cause the cleaning nozzle **118** to resume the path from the current position.

[0028] Referring now to FIG. **2**A, a schematic diagram of a system **200**A representing a clog detection assembly **200** including Light Dependent Resistor (LDR) for detecting a clog in a component associated with a heat exchanger is disclosed, in accordance with an embodiment of the present disclosure. The system **200**A may include LDR sensors **202**. The sensors may further include a sensor **202***a*, which may include a Lux value **204***a* and a resistance **206***a*. Similarly, the system **200**A may include a sensor 2 **202***b*, which may include a lux value 2 **204***b* and a resistance 2 **206***b*. Further the system **200**A may include sensor 3 **202***c*, which may include a lux value 3 **204***c* and a resistance 3 **206***c*. It may be noted that number of sensors is not limited to three. Other sensors may also be added to determine their average. It may also be noted that the lux value may range from 0 to 3000. The system **200**A further represents expended view of the sensor 1 **202***a*, having lux value 1 **204***a* and resistance 1 **206***a*.

[0029] The system **200**A may include a light source (similar to light source **110**) configured to be positioned on a first side of the heat exchanger component and illuminate the heat exchanger component. A light detector may be configured to be positioned on a second side opposite the first side of the heat exchanger component and receive the light transmitted by the light source upon passing through the heat exchanger. The system **200**A may be configured to receive a signal indicative of clog extent value, compare the clog extent value with a threshold clog value, and determine the presence of the clog cleaning based on the comparison.

[0030] Referring now to FIG. **2**B, a schematic diagram of a system **200**B for conversion of luminance to resistance and conversion of resistance to voltage is illustrated, in accordance with an embodiment of the present disclosure. The system **200**B may include a voltage divider **208**. The voltage divider **208** may further include an input voltage (Vin) **210**, a LDR **212**, an output voltage (Vout) **214**, a resistance R2 **216**. The voltage divider **208** may activate upon receiving a light of intensity **218**. It may further be noted that the output voltage **214** may be determined as per equation, given below:

$$V_{out}=V_{in}\times(R_2/(R_{LDR}+R)) \qquad \text{equation (1)}$$

[0031] It should be noted that in some embodiments, data acquisition (DAQ) may be used for conversion of luminance to resistance and for conversion of resistance to voltage. As such, a lookup table may be created and used via interpolation.

[0032] Referring now to FIG. **3**, a dashboard **300** of a system for detecting a clog and cleaning the clog is illustrated, in accordance with an embodiment of the present disclosure. As illustrated, the dashboard **300** may be designed using a simulation tool software which are commonly available in the market. Heat Exchanger cleaner dashboard may display a heat exchanger ON/OFF switch **302***a*, a Dashboard ON/OFF switch **302***b*, a clog detection ON/OFF switch **302***c*, a cleaning enable switch **302***d*, and an emergency stop switch **302***e*. In addition, different light intensity values **304** are shown. A light intensity value may be received at the LDRs along with clog percentage **312**. A user may verify clog percentage **312** once again after the cleaning process is completed. Further, graphs **306** for various states of motors and valve controls along with a clog present signal **308** and a cleaning status **310** is displayed on the dashboard **300**.

[0033] In an embodiment, a process flow in automatic detection and cleaning of the heat exchanger component may include the steps of: (i) turning OFF the heat exchanger system, (ii) turning ON the heat exchanger cleaning system from the dashboard, (iii) turning ON the heat exchanger clog detection switch, (iv) detecting clog from dust and debris using light source which may be (LED) and LDRs. The detection may be done using a following method, where a light intensity may be converted to resistance using LDRs. Theoretically, resistance may be converted to voltage using a voltage divider and after a calibrated drop of voltage, the cleaning process may be started. (v) If voltage comes below a calibrated value, the 'Clog Detected' LED may turn ON and if display feature is available, a percentage of clog may be detected. Then, the 'Cleaning Enable Switch' may be turned 'ON'. On turning the switch 'ON' determine whether if the red LED appears indicating the presence of clog condition comes up. If the LED doesn't come up, it implies that the components are not fully clogged, and the cleaning process need not be initiated. (vi) An 'Emergency Stop Switch' may be present in the dashboard **300** to shut down the whole cleaning process in case of any emergency. If this is pressed, the whole cleaning process may be restarted by its own. This feature may enable the system to reset in case of any sudden power cut or any other unfavorable situations as well. (vii) Further, for the cleaning process to start first, the system may check for the compact box (containing the cleaning nozzle **118**) in a homing position, and if the compact box is not in the homing position, the system may bring it to homing position first which is very necessary for the compact box to start executing the cleaning path. (viii) Once the compact box is in homing position which is detected by the stop switches, the cleaning process may start. (ix) Further, the cleaning process may make the compact box follow a specific optimized path to cover a specific coil area. The movement may be controlled by two motors with help of two lead screw rods. The movement may start from the homing position and the ending point may also be at same location. So, while traveling from the homing position, the compact box may spray a pressurized cleaning agent via a multiport valve and while returning the compact box may force pressurized gaseous fluid thus cleaning the coil clog. (x) Finally, after cleaning process, the system may be turned OFF.

[0034] Referring now to FIG. **4**, a framework **400** of a system for detecting a clog and cleaning the clog automatically is illustrated, in accordance with an embodiment of the present disclosure. As illustrated, the framework **400** may include a clog initiation block **402**, a clog detection block **404**, and a clog cleaning block **406**. The clog initiation block **402** may further include various switches (as illustrated in the dashboard **300**) including a power switch **402***a*, an emergency stop-switch **402***b*, HVAC status **402***c*, UI clog detection switch **402***d*, a cleaning enable switch **402***e*. The framework **400** further includes various signals which supports the system to further initiate the detection and cleaning of the clog. The signals may include a clog present signal **402***f* a cleaning enabling signal **402***g*, a clog present signal **402***d*, and a detection enabling signal **402***h*. The clog present signal **402***f* may signify the presence of the clog and the detection enabling signal **402***h*, may signify the detection of the clog.

[0035] Further the framework **400** may include a clog detection block **404**. In some example embodiments, the clog detection block **404** may include three lux values, i.e. a lux value1 **404***a*, a lux value2 **404***b*, and a lux value3 **404***c*. In alternate embodiments, any other number of three lux values may be used as well, i.e. the number of three lux values may vary based on the number of LDRs used. The clog detection block **404** may further include the clog present signal **404***d* to detect the presence of clog and a clog percentage signal **404***e*, which may represent the percentage of the present clog (on the dashboard) and compare it further with a predefined clog threshold value. Further the framework **400** may include a clog cleaning block **406**, which may initiate the clog cleaning process upon receiving the cleaning enable signal **402***g* from the clog initiation block **402**. The cleaning block **406** further includes a longitudinal motor I/P **406***a* to activate the longitudinal motor **408**, a lateral motor I/P **406***b* to activate the lateral motor **410**, a reservoir valve **406***c*, a compressor valve **406***d*, and a cleaning status **406***e*. Cleaning may be further explained in detail in conjunction with FIGS. **5-10**.

[0036] Referring now to FIG. **5**, a schematic circuit diagram **500** of a sub-system of the system of FIG. **4** for triggering detection of a clog is illustrated, in accordance with an embodiment of the present disclosure. In an embodiment, conditions to start detection of the clog may include: (a) The system may be turned OFF before starting a detection and a cleaning process as it may hamper an ongoing process, and (b) user should turn on the switch for auto detection and cleaning. If the components are clogged, then the cleaning system may start cleaning the components and for rest of the time, the system may be at rest. The clog detection system may be initiated by the user, upon activating the switches from the dashboard. The sub-system may include a switch for power **502**, an emergency stop switch **504**, an HVAC status**506**, a cleaning enable switch **508**, and a clog present signal **510**. The power **502**, the emergency stop switch **504**, the HVAC status**506** may activate the detection enabling signal **514** upon receiving a signal from a UI clog detection switch **512**. A value at UI clog detection switch **512** may be determined by performing "AND" operation on values corresponding to the power **502**, the emergency stop switch **504**, the HVAC status**506**. Further, the cleaning enable switch **508** and the clog present signal **510** upon activation may generate the cleaning enabling signal **516**. A value at the cleaning enabling signal **516** may be generated by performing an "AND" operation on values corresponding to the cleaning enable switch **508** and the clog present signal **510**. Further, the cleaning enabling signal **516** and clog present signal **510** may be responsible for a clog present signal **518**.

[0037] Referring now to FIG. **6**, a schematic circuit diagram **600** of a sub-system of the system of FIG. **4** for detecting the clog is illustrated, in accordance with an embodiment of the present disclosure. With respect to FIG. **6** the clog may be detected using a light source and a light detector which may be a photodiode. According to the light intensity, an output voltage may be obtained in a processing device And, by iterations over a cleaned component, a value of intensity of light may be passed through the cleaned component. Further, when less than calibrated voltage is obtained, it may be inferred that dust may be clogging the component. After a threshold drop in the voltage, a cleaning process may be initiated. As may be appreciated, multiple LDRs may be used for cleaning the components. Further, an average of them may be taken for comparison and if found less than the threshold, a cleaning switch (similar to the cleaning switch **302***d*) may be pressed. Hence, the cleaning process may be executed. The sub-system may include LEDs **602**, LSR sensors **604**, a resistance to voltage block **606**.

[0038] The LEDs **602** may be used to indicate presence and condition of the clog. The LDR sensors **604** may receive lights of various intensities as an input including a lux value1 **604***a*, a lux value2 **604***b*, and a lux value3 **604***c*, depending on the number of LDRs used. As mentioned above, the number of the lux values may not be restricted to 3 and may vary based on the number of LDRs used according to the requirement. Further, output of the LDR sensors **604** may be a resistance1 **604***d*, a resistance2 **604***e* and a resistance3 **604***f* depending on the number of LDRs used. The number of resistances may vary corresponding to the number of lux values, and therefore may not be limited to 3. It may be noted that an average of the lux values and corresponding resistances may be determined. An average resistance value **606***a* may be transmitted to the resistance to voltage unit **606**. The resistance to voltage unit **606** may further output a voltage **606***b*. Further, based on the voltage **606***b*, a clog percent signal may be generated, and a clog percentage may be determined.

[0039] Referring now to FIG. **7**, a schematic circuit diagram **700** of a sub-system of the system of FIG. **4** for cleaning the clog is illustrated, in accordance with an embodiment of the present disclosure. With respect to FIG. **7**, the sub-system represents a cleaning block and in the cleaning block a counter may be maintained for keeping a count of time. Using the count of time maintained, all the processes of the system for servicing the heat exchanger may be synchronized. Both motors in 'x' and 'y' directions may be synchronized to cover whole area of duct and thus spray cleaning agent to the components (air side) and then clean the components with a pressurized gaseous fluid (e.g., air) spray. In an embodiment, there may be an initial check of homing position before starting the cleaning path. In addition, a path for the clog cleaning may be generated in real time

[0040] The cleaning block may include a counter **702** for keeping a count of a time **702***a*. The counter **702** may be coupled to motor modules, a cleaning agent reservoir, and a gas compressor valve to initiate their respective timely responses. The cleaning block may further include a motor command **706**, which may further include MotX **706***a*, MotY **706***b* and a cyclestart **706***c*. It should be noted that MotX and MotY are negative motion for the compact box to go to a homing position till the cycle start signal is actuated for the cleaning process startup. The motor command **706** may further receive information from the homing position (the terms 'homing position' and 'first position' may have been used interchangeably in this disclosure) detection block **704**. The homing position detection block may further include X axis Stop Switch **704***a* and a Y axis StopSwitch **704***b*. The homing position detection block **704**, upon receiving the processor executable instructions, may command the motors to locate and move towards the homing position when required.

[0041] The motor modules may include a longitudinal motor module **714** which may be associated with a longitudinal motor **714***a*. The motor modules may include may further include a lateral motor module **716** which may be associated with a lateral motor **716***a*. The cleaning block may include a valve key for cleaning agent spraying **718** associated with a reservoir valve **718***a* and a valve key for air compressor **720** associated with a compressor valve **720***a*. The system may further include represent a cleaning status **708**.

[0042] Referring now to FIG. **8**, a path of movement **800** which may be followed by the cleaning nozzle (similar to the cleaning nozzle **118**) for cleaning the heat exchanger component is illustrated, in accordance with an embodiment of the present disclosure. With respect to FIG. **8**, the cleaning nozzle (within a compact box) may follow a "S type" path to cover the whole component area. In some embodiments, the path may be generated automatically based on an area of the component. It should be noted that information related to the area (length and breadth), for example the coil area, may be provided manually. The path shape may be optimized in case of larger component area in other models. A homing position **802** may be attained with help of stop switches (for example, the X axis stop switch **704***a* and Y axis stop switch **704***b*). Further, movement may be controlled using two stepper motors, two stop switches, and two screw rods. As an example, time to cover each horizontal distance (of the "S type" path) of the component may be '5' seconds and time to cover vertical distance (of the "S type" path) across the component may be '1' second, based on the lead of screws and speed (RPM) of the motors. Therefore, while going from the homing position **802** (the first position) to a path end position (the terms 'path end position' and 'second position' may have been used interchangeably in this disclosure) the second position) it may spray cleaning agent and while returning it may force gaseous fluid and thus complete the cleaning process. The flow of the cleaning agent through the air compressor or blower may be controlled by the multiport cleaning nozzle.

[0043] The homing position **802** may be determined by a processing device, a component area **804**, a path end position **806** (which may be a last working point of the component). It may be noted that the path of movement **800** may include a first cycle **808**, which may be followed by the cleaning nozzle during the movement from the homing position **802** towards the path end position **806**. Further, the path of movement **800** may include a return cycle **810**, which may be followed by the cleaning nozzle during the movement from the path end position **806** towards the homing position **802**.

[0044] Referring now to FIG. **9**, graphical representations **900** of a movement of a cleaning nozzle are illustrated, in accordance with an embodiment of the present disclosure. The cleaning nozzle may follow the paths depicted by the various graphs for performing the movement of the nozzle via the motor(s). The graphical representations **900** include a graph **902** which represents movement of a horizontal motor throughout the cycle. The horizontal motor may be a longitudinal motor **902***a*. Further, the graphical representations **900** include a graph **904** which represents movement of the vertical motor (a lateral motor **904***a*) throughout the cycle. The graphical representations **900** further include a graph **906** which represents a time vs activation graph for the spraying of cleaning agent from the reservoir. The graph **906** may include a reservoir valve actuation value **906***a*, which is representative of fluid spray status. The graphical representations **900** may further include a graph **908** which represents a time vs activation graph for the spraying of compressed air from the compressor or blower. The graph **908** may include a compressor valve actuation value **908***a* which is representative of compressed air status from the compressor.

[0045] Referring now to FIG. **10**, a method for servicing a heat exchanger is depicted via a flowchart **1000**, in accordance with an embodiment. FIG. **10** is explained in conjunction with FIGS. **1-9**. Each step of the flowchart **1000** may be executed by various modules (same as the modules of the system **1000**).

[0046] At step **1002**, a first signal corresponding to a transmitted light may be received. In particular, the signal may be received from a light detector (similar to the light detector **112**). It should be noted that the light detector may be configured to detect transmitted light in response to a projected light beam projected by a light source (same as the light source **110**) and transmitted through a component associated with the heat exchanger. Additionally, it should be noted that the light detector may be positioned on a second side of the component associated with the heat exchanger.

[0047] At step **1004**, a first signal may be analyzed. The first signal may analyzed to detect presence of a clog in association with the component. It may be noted that the analysis of the signal may be executed by a clog detection assembly (analogous to the clog detection assembly **108**) and a processing device (same as the processing device **102**).

[0048] Thereafter, at step **1006**, upon detection of the presence of the clog in a cleaning process may be performed to clean the clog detected in association with the component. Cleaning may be performed in various steps **1006***a*-**1006***c*. At step **1006***a*, a cleaning nozzle (same as the cleaning nozzle **118**) may be moved across the component along a path. The path may be defined between a first position and a second position relative to the component. Thereafter, at step **1006***b*, a clog cleaning agent may be sprayed on the component during its movement along the path by the cleaning nozzle, from the first position to the second position. At step **1006***c*, a pressurized fluid may be sprayed on the component during its movement along the path using the cleaning nozzle, from the second position to the first position relative to the component.

[0049] The disclosed invention works using LDRs which may detect an amount of light and may detect that the components are clogged or not. As is known, that as luminance varies as resistance varies and may be captured by supplying voltage. Thus, voltage may also vary. After a drop in voltage if a user switches to an auto clean, the system may start its automatic cleaning process. Further, the components may be cleaned by both a cleaning agent and pressurized air. Thus, whole cleaning process may be carried out without human efforts and in a very small span of time which may be calibrated by altering the codes.

[0050] The disclosed invention may enable the disclosed system to be both retrofitted and when given as an additional feature with heat exchanger systems would be a great impact to business. The system is very economical and may drastically reduce human effort for cleaning purposes. The system is robust and may need no maintenance of its own. The system may be able to clean the components in minimum amount of time. Further, the system may involve minimal cost and include multiple LDRs and LEDs, two stepper motors, two lead screw rods, two stop switches, one compressed gaseous fluid source (e.g., a compressor or a blower) and one microprocessor which can be standard of the self and can be reprogrammed as per the logic. The system may be robust and thus may have no need of maintenance as only a cleaning agent may be filled. In addition, no human efforts may be needed for opening the ducts and cleaning manually. The system may be incorporated in the heat exchanger system itself and thus may be powered from there or may be a separate unit be made for taking the power. The system may be calibrated depending on availability of light intensity present and may be configured separately for smooth detection of foreign particles such as dust and debris. As may be appreciated, if source of compressed gaseous fluid is present, then there may be no need to install a compressor or a blower and thus cost may be very less. Further, a smart application may be made to clean the components remotely and get notifications on personal/handheld or any other devices for cleaning when the components are clogged.

[0051] It is intended that the disclosure and examples be considered as exemplary only, with a true scope and spirit of disclosed embodiments being indicated by the following claims.

What is claimed is:

1. A system for servicing a heat exchanger, the system comprising:

a clog detection assembly comprising:

a light source configured to be positioned on a first side of a component associated with the heat exchanger and further configured to illuminate the component with a projected light beam;

a light detector configured to be positioned on a second side opposite to the first side of the component and further configured to detect transmitted light, in response to the projected light beam transmitting through the component, to generate a first signal corresponding to the transmitted light; and

a processing device communicatively coupled to the light detector, the processing device comprising:

a processor; and

a memory configured to store processor-executable instructions, wherein the processor-executable instructions, upon execution by the processor, cause the processor to:

receive, from the light detector, the first signal corresponding to the transmitted light; and

analyze the first signal to detect presence of a clog in association with the component.

2. The system as claimed in claim **1** further comprising:

a clog cleaning assembly communicatively coupled to the processing device, the clog cleaning assembly comprising:

a cleaning nozzle configured to:

move across the component;

spray a clog cleaning agent on the component; and

upon spraying the clog cleaning agent, spray a pressurized fluid on the component.

3. The system as claimed in claim **2**, wherein the processor-executable instructions further cause the processor to:

cause the cleaning nozzle to move across the component along a path,

wherein the path is a predefined path, and

wherein the path is defined between a first position and a second position relative to the component.

4. The system as claimed in claim **2**, wherein the path is generated in real time, based on the analysis.

5. The system as claimed in claim **3**, wherein the processor-executable instructions further cause the processor to:

cause the cleaning nozzle to spray the clog cleaning agent on the component during its movement along the path, from the first position to the second position relative to the component; and

cause the cleaning nozzle to spray the pressurized fluid on the component during its movement along the path, from the second position to the first position relative to the component.

6. The system as claimed in claim **3**, wherein the processor-executable instructions further cause the processor to:

obtain a current position of the cleaning nozzle; and

cause the cleaning nozzle to return to the first position, by moving along a reset path,

wherein the reset path is generated based on a predefined criterion.

7. The system as claimed in claim **6**, wherein the processor-executable instructions further cause the processor to cause the cleaning nozzle to resume the path from the current position.

8. The system as claimed in claim **6**, wherein the predefined criterion is selected from a set of predefined criteria, the set of predefined criteria comprising:

a first predefined criteria, based on a shortest path between the current position and the first position;

a second predefined criteria, based on a quickest travel path between the current position and the first position; and

a third predefined criteria, based on a least operation time of one or more motors configured to cause the cleaning nozzle to move between the current position and the first position.

9. The system as claimed in claim **1**, wherein the light detector is a photodiode configured to:

detect intensity of the transmitted light to determine a detected intensity value, in response to the projected light beam transmitting through the component, to generate the first signal corresponding to the transmitted light.

10. The system as claimed in claim **9**, wherein analyzing the first signal to detect presence of the clog comprises at least one of:

comparing the detected intensity value of the transmitted light with a rated intensity value associated with the light source; or

comparing the detected intensity value of the transmitted light with a predefined threshold intensity value.

11. A method of servicing a heat exchanger, the method comprising:

receiving, from a light detector, a first signal corresponding to a transmitted light,

wherein the light detector is positioned on a second side of a component associated with the heat exchanger, the light detector further configured to detect transmitted light in response to a projected light beam projected by a light source and transmitting through the component, to generate the first signal corresponding to the transmitted light, wherein the light source is positioned on a first side of the component opposite to the second side; and

analyzing the first signal to detect presence of a clog in association with the component;

upon detecting presence of the clog in association with the component, cause a cleaning nozzle to:

move across the component along a path, wherein the path is defined between a first position and a second position relative to the component;

spray a clog cleaning agent on the component during its movement along the path, from the first position to the second position; and

spray a pressurized fluid on the component during its movement along the path, from the second position to the first position relative to the component.

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