US012392516B2

(12) **United States Patent**
Kunchala

(10) **Patent No.: US 12,392,516 B2**
(45) **Date of Patent: Aug. 19, 2025**

(54) **SYSTEM AND METHOD FOR IDENTIFYING CLOGGED EVAPORATOR COIL**

(71) Applicant: **Carrier Corporation**, Palm Beach Gardens, FL (US)

(72) Inventor: **Sai Krishna Kunchala**, Hyderabad (IN)

(73) Assignee: **CARRIER CORPORATION**, Palm Beach Gardens, FL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 218 days.

(21) Appl. No.: **17/988,411**

(22) Filed: **Nov. 16, 2022**

(65) **Prior Publication Data**

US 2023/0160588 A1 May 25, 2023

Related U.S. Application Data

(60) Provisional application No. 63/282,277, filed on Nov. 23, 2021.

(51) **Int. Cl.**

F24F 11/38 (2018.01)
F24F 11/52 (2018.01)
F24F 11/56 (2018.01)
F24F 11/62 (2018.01)
F24F 13/22 (2006.01)

(52) **U.S. Cl.**

CPC ***F24F 11/38*** (2018.01); ***F24F 11/52*** (2018.01); ***F24F 11/56*** (2018.01); ***F24F 13/222*** (2013.01)

(58) **Field of Classification Search**

CPC .. F24F 11/38; F24F 11/52; F24F 11/56; F24F 11/30; F24F 13/222

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,337,576 A	8/1994	Dorfman et al.	
10,480,875 B2	11/2019	Metropoulos	
10,486,082 B2	11/2019	Deivasigamani et al.	
2004/0083029 A1 *	4/2004	Bicknell	G05D 23/1931 700/276
2009/0071181 A1	3/2009	Spanger	
2013/0304532 A1 *	11/2013	Cormier	F24F 11/38 705/7.15
2019/0203976 A1	7/2019	Scott et al.	
2019/0338976 A1	11/2019	Chakraborty et al.	
2020/0041374 A1 *	2/2020	Deivasigamani	G01M 3/04
2020/0256578 A1	8/2020	Meis et al.	
2021/0389026 A1 *	12/2021	Wu	F24F 5/0071

FOREIGN PATENT DOCUMENTS

CN	100560316 C	11/2009
CN	203616275 U	5/2014
CN	110092488 A	8/2019
CN	209744648 U	12/2019
CN	214348238 U	10/2021
EP	3168555 B1	11/2020
IN	202041039512	9/2020
JP	2038965 A *	2/1990
WO	2018110806 A1	6/2018

* cited by examiner

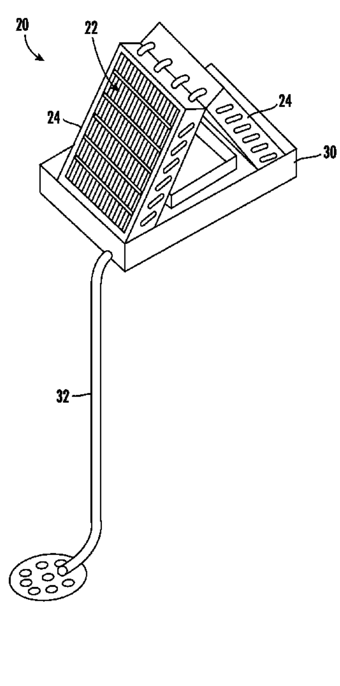
Primary Examiner — Marc E Norman

(74) *Attorney, Agent, or Firm* — CANTOR COLBURN LLP

(57) **ABSTRACT**

A method for evaluating a heat exchanger of an air conditioning system includes measuring a pH level of a condensate of the heat exchanger and determining a condition of the heat exchanger in response to the pH level.

15 Claims, 5 Drawing Sheets



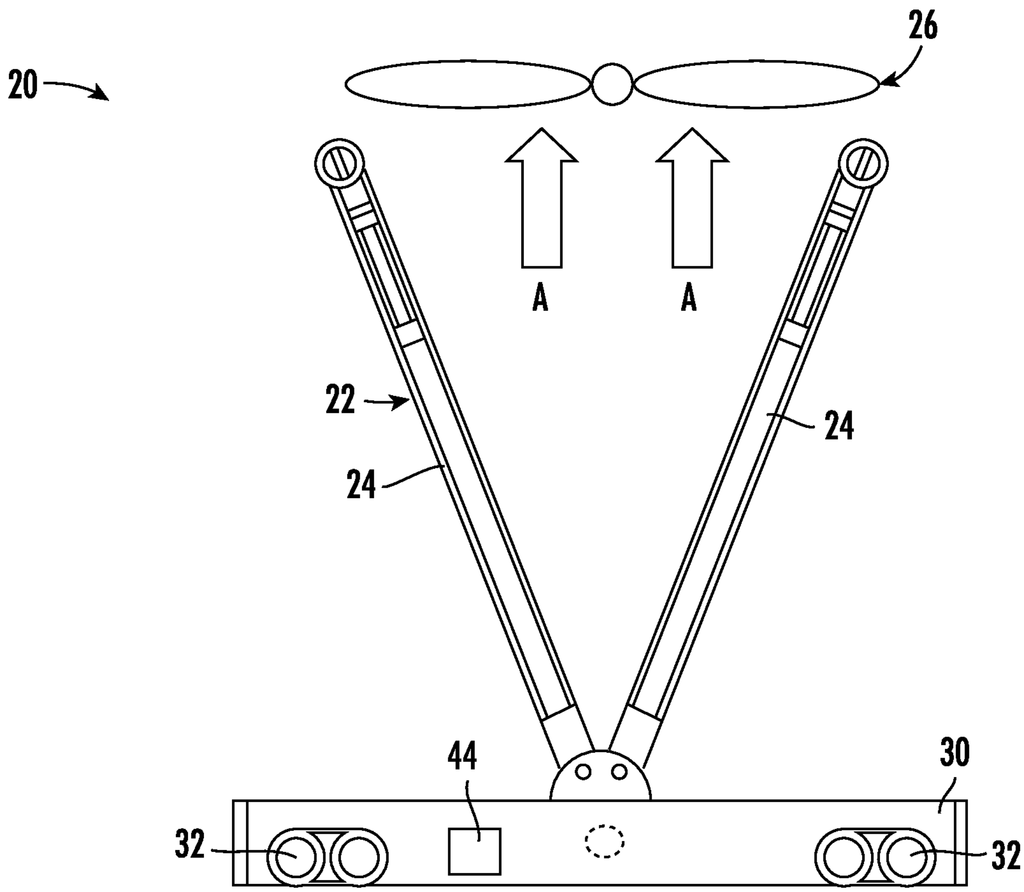


FIG. 1

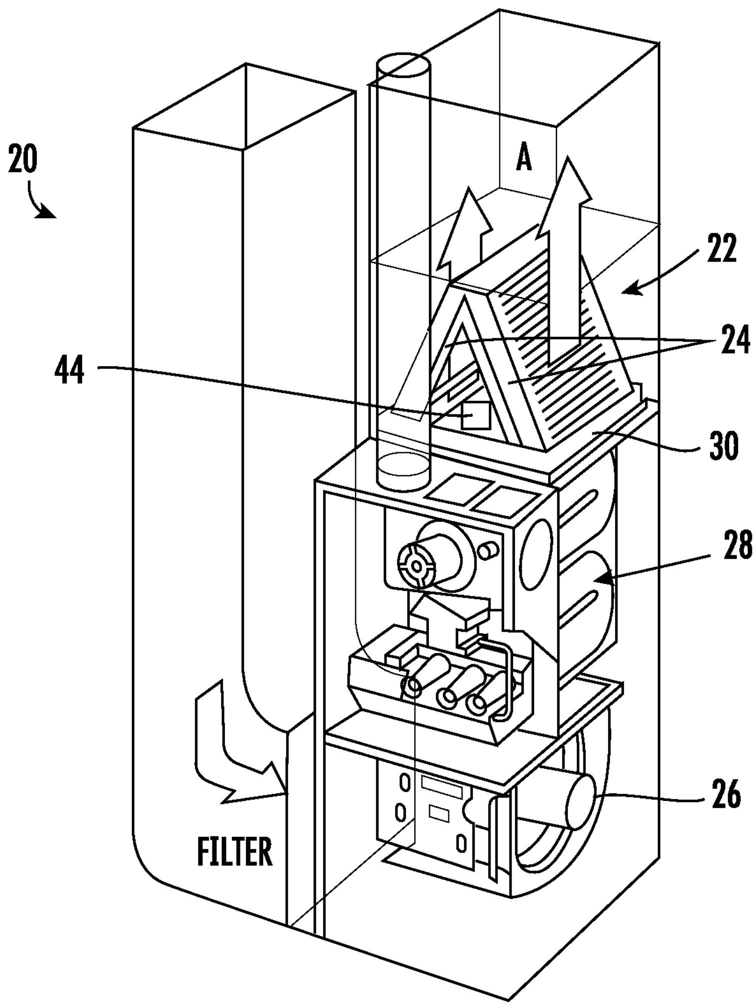


FIG. 2

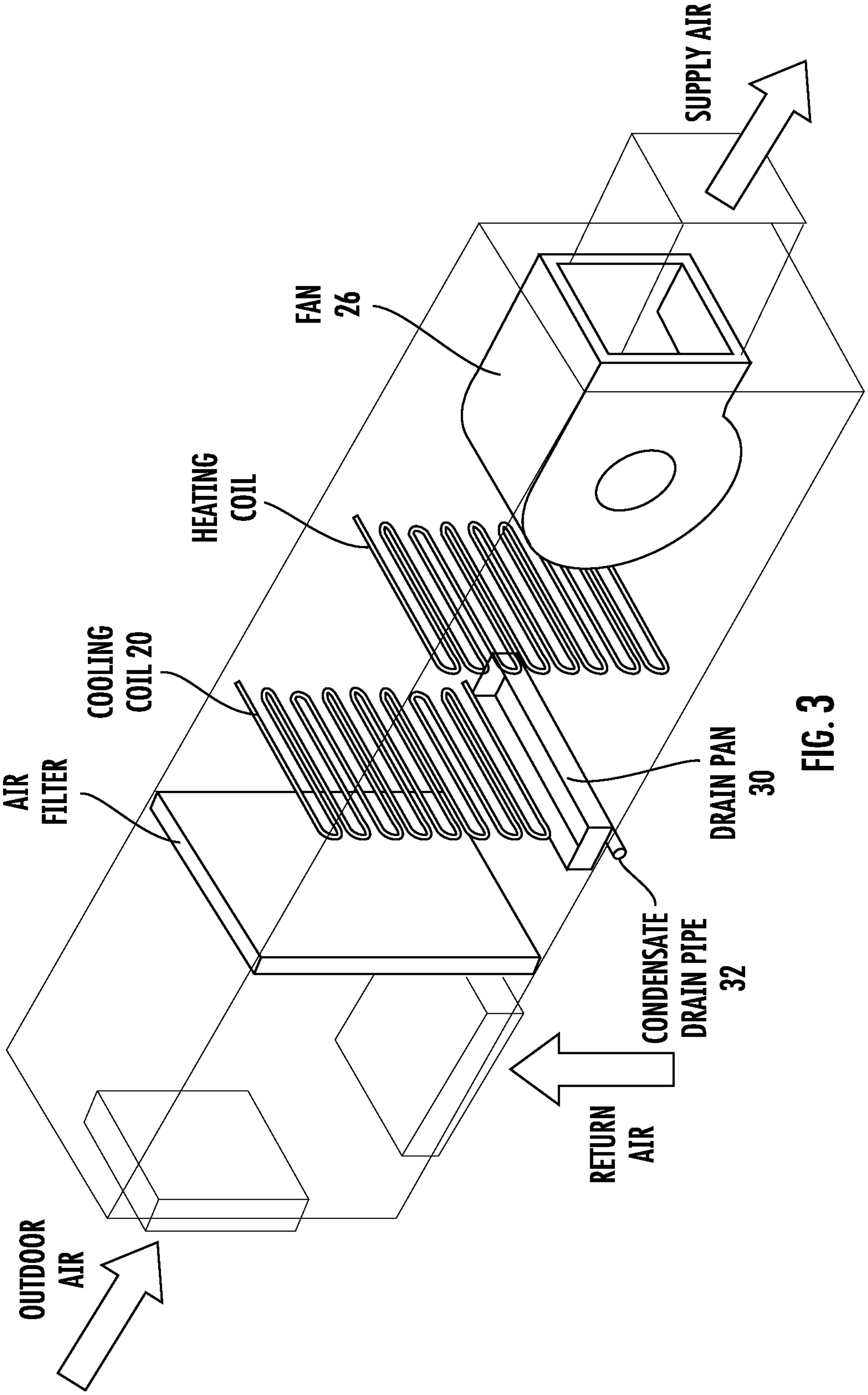

SUPPLY AIR
FAN 26
HEATING COIL
COOLING COIL 20
AIR FILTER
DRAIN PAN 30
CONDENSATE DRAIN PIPE 32
RETURN AIR
OUTDOOR AIR

FIG. 3

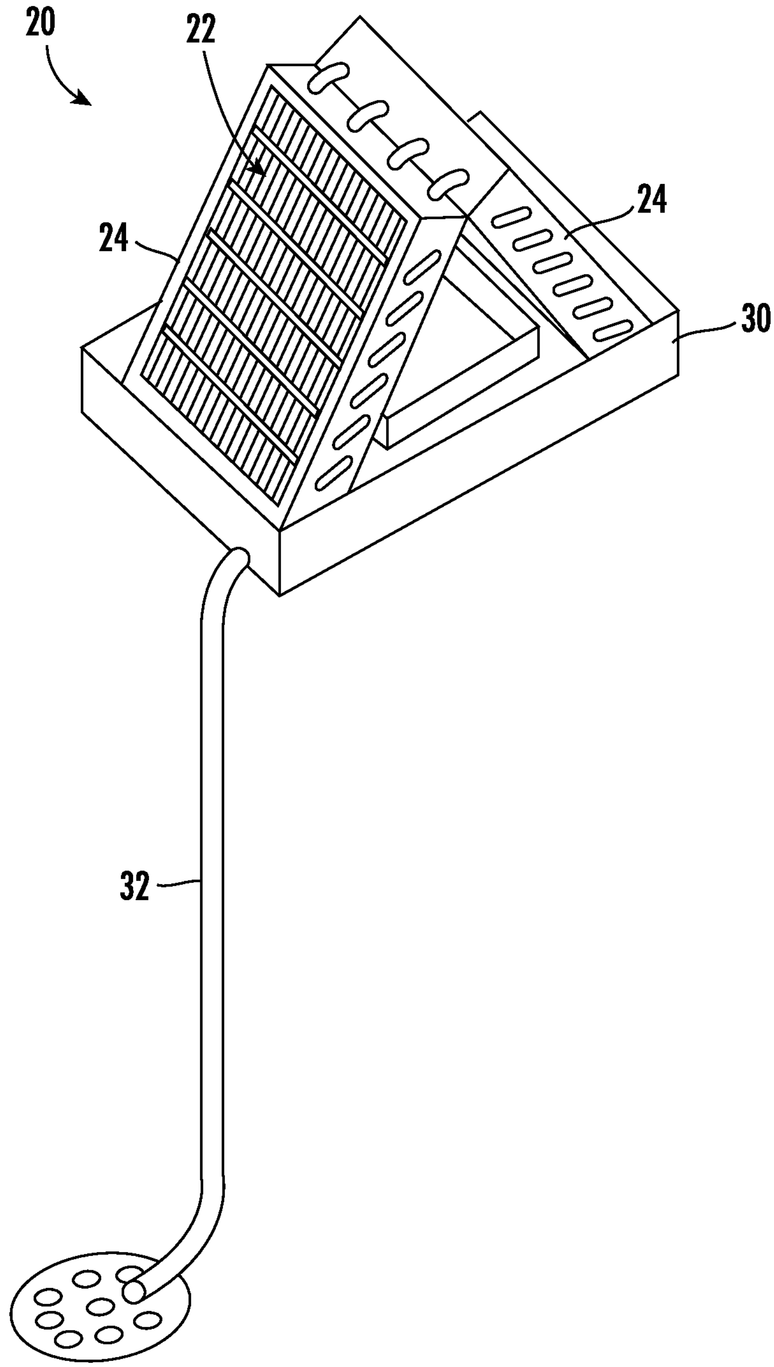


FIG. 4

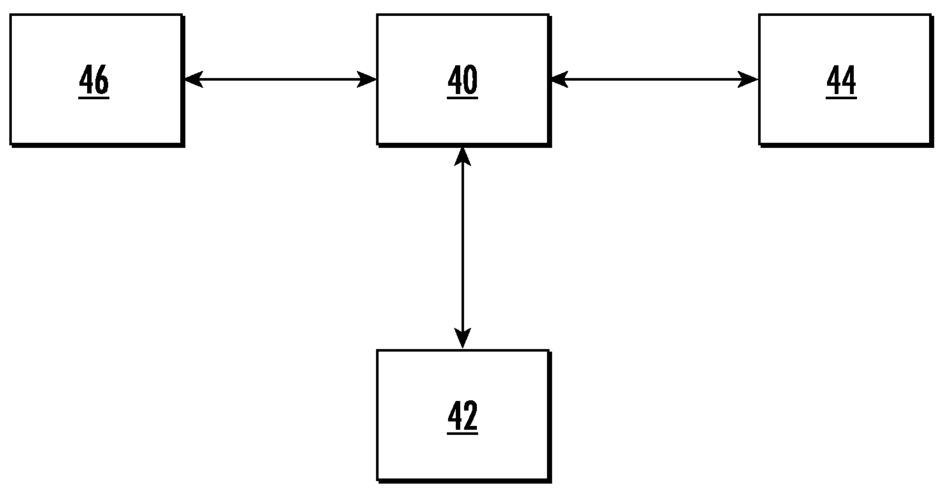


FIG. 5

SYSTEM AND METHOD FOR IDENTIFYING CLOGGED EVAPORATOR COIL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 63/282,277 filed Nov. 23, 2021, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

Embodiments of the present disclosure relate to the art of air conditioning systems, and more particularly, to the condition of a heat exchanger of an air conditioning system.

Most air conditioning systems typically include one or more filters operable to capture dust, dirt, debris, and other particles within the air flow of the system. However, these filters are not able to trap all of the particulate matters within the air flow. As a result, over time, this particulate matter can accumulate on the exterior of the heat exchanger, such as the fins thereof. Because this particulate matter makes the heat exchanger less efficient in absorbing heat from the air, the remainder of the air conditioning system must compensate by running at a high power and consuming more energy.

BRIEF DESCRIPTION

According to an embodiment, a method for evaluating a heat exchanger of an air conditioning system includes measuring a pH level of a condensate of the heat exchanger and determining a condition of the heat exchanger in response to the pH level.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments comprising operating an indicator in response to the pH level to indicate a need for service.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments the indicator is associated with a component of the air conditioning system that is visible by a user.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments the component is a thermostat.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments the indicator is associated with a component of the air conditioning system that is visible by a service man.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments measuring the pH level of the condensate of the heat exchanger is performed automatically by a pH sensor.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments comprising comparing the pH level to a first threshold and in response to determining that the pH level is less than the first threshold, comparing the pH level to a second threshold.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments in response to determining that the pH level is less than or equal to the second threshold, communicating with a remote system a need for immediate service.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments in response to determining that the pH level is between the first threshold and the second threshold, estimating a date by which service will be required.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments measuring the pH level of the condensate of the heat exchanger is performed manually.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments measuring the pH level of the condensate is performed using one of a pH test strip, a pH meter, and a colorimeter.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments determining the condition of the heat exchanger in response to the pH level further comprises comparing the pH level to a correlated table.

According to an embodiment, an air conditioning system includes a heat exchanger, a pH sensor operable to monitor a pH level of a condensate from the heat exchanger, and a controller configured to receive the pH level of the condensate from the pH sensor and compare the pH level to at least one threshold to determine a condition of the heat exchanger.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments comprising a condensate drain pan disposed vertically beneath the heat exchanger.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments the pH sensor is arranged within the condensate drain pan.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments the controller is further configured to operating an indicator in response to the pH level to indicate a need for service.

In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments the controller is further configured to communicate a need for immediate maintenance.

BRIEF DESCRIPTION OF THE DRAWINGS

The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

FIG. **1** is a front view of an example of a heat exchanger of an air conditioning system;

FIG. **2** is a perspective view of a portion of an air conditioning system including a heat exchanger according to an embodiment;

FIG. **3** is a perspective view of an air conditioning system including a heat exchanger according to an embodiment;

FIG. **4** is a detailed perspective view of a heat exchanger and a condensate drain pan according to an embodiment; and

FIG. **5** is a schematic diagram of a control system of an air conditioning system according to an embodiment.

DETAILED DESCRIPTION

A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

With reference now to FIG. **1**, an example of a portion of an air conditioning system **20** is illustrated. As used herein, the term "air conditioning system" is intended to include a heating, ventilation and air conditioning (HVAC) system and/or a refrigeration system including both single unit and split package systems. As shown, the portion of the air conditioning system **20** includes a heat exchanger **22** having at least one heat exchanger coil **24**. In an embodiment, the heat exchanger **22** may be configured as an evaporator within the air conditioning system **20**. It should be understood that embodiments where the heat exchanger is configured as a condenser are also contemplated herein.

In the illustrated, non-limiting embodiment, the heat exchanger **22** includes a plurality of heat exchanger coils **24** configured as a V-coil. However, it should be understood that a heat exchanger **22** having any number of coils **24**, such as a single coil, or more than two coils for example, is within the scope of the disclosure. Further, in embodiments having multiple coils **24**, it should be understood that coils **24** configured in an A-shape (see FIG. **2**), a W-shape, an M-shape, or another suitable shape are also contemplated herein. The plurality of coils **24**, may be fluidly coupled to one another, or alternatively, may be separate from one another.

The heat exchanger **22** may be any suitable type of heat exchanger configured to transfer heat between a refrigerant and air or another medium. For example, the heat exchanger **22** may include one or more coils of thermally conductive material, such as copper, aluminum, alloys thereof, or combinations thereof. In other embodiments, the heat exchanger **22** may be a shell-and tube heat exchanger, a printed circuit heat exchanger, a plate-fin heat exchanger, a microchannel heat exchanger, or any combination thereof.

A movement mechanism **26**, such as a fan or blower for example, is configured to move a cooling medium, such as a flow of air A for example, across the one or more coils **24** of the heat exchanger **22**. Although the movement mechanism **26** is illustrated as being disposed vertically above the heat exchanger **22**, and therefore in a draw-through configuration, it should be understood that embodiments where the movement mechanism **26** is positioned in a blow-through configuration, such as a blower **26** disposed vertically beneath a furnace **28** operably coupled to the heat exchanger **22** (see FIG. **2**) for example, are also within the scope of the disclosure. Although a residential air conditioning system **20** is illustrated in FIG. **2**, it should be understood that the heat exchanger illustrated and described herein may also be used in a commercial air conditioning system, such as shown in FIG. **3** for example.

With continued reference to FIGS. **1-3**, and further reference to FIG. **4**, disposed vertically beneath the heat exchanger **22** is a condensate drain pan **30**. The drain pan **30** is configured to capture or collect condensation that accumulates on and/or drips from the one or more heat exchanger coils **24** of the heat exchanger **22**. One or more conduits or channels **32** fluidly coupled to or formed in the drain pan **30** are configured to direct the condensate collected within the drain pan **30** outside of the air conditioning system **20** or to another component within the air conditioning system **20**.

With continued operation of the air conditioning system **20**, dirt, debris, and other particles may collect on the exterior surface of the heat exchanger **22**, such as between the fins of the or more heat exchanger coils **24**, thereby blocking, at least partially, the flow path through or across the heat exchanger **22**. As this particulate matter accumulates and clogs the flow path, the heat transfer between the refrigerant within the heat exchanger **22** and the air A is hindered, thereby lowering the efficiency of the air conditioning system **20**. In instances where no or minimal particulate matter is present on the heat exchanger **22**, the condensate that falls from the heat exchanger **22** to the drain pan **30** is primarily water having a generally neutral pH level. However, as the particulate matter accumulates on the heat exchanger **22**, the condensate that drips from the heat exchanger **22** to the drain pan **30** is a mixture of water and the particulate matter. As a result, the pH level of the condensate within the drain pan **30** will change due to the presence of the particulate matter therein.

With reference now to FIG. **5**, the air conditioning system **20** includes a controller **40** having one or more of a microprocessor, microcontroller, application specific integrated circuit (ASIC), or any other form of electronic controller known in the art. The controller **40** is operably coupled to one or more components of the air conditioning system **20**, such as the movement mechanism **26** or a compressor (not shown) for example, to control operation thereof. A thermostat **42** for selecting a temperature demand of the area to be conditioned by the air conditioning system **20** is arranged in communication with the controller **40**. In an embodiment, the controller **40** is configured to control operation of the air conditioning system **20** in response to the temperature setting of the thermostat **42**.

In an embodiment, the air conditioning system **20** additionally includes at least one sensor **44** operable to automatically monitor a pH level of the condensate within the drain pan **30**. The sensor **44** may be mounted directly within the condensate drain pan **30** or within a conduit fluidly coupled to the drain pan **30**. Alternatively, the sensor **44** may be mounted at any other suitable location, including at a location external to air conditioning system **20** where condensate is collected, such as the condensate line or drain pipe **32** for example. The sensor **44** may be configured to continuously monitor and communicate the pH level of the condensate to the controller **40**, or alternatively, may be configured to intermittently monitor and communicate the pH level of the condensate to the controller **40**.

In response to a signal from the pH sensor **44**, the controller **40** may be configured to evaluate a condition of the heat exchanger **22**, such as the blockage of the flow across or through the fins of the heat exchanger **22**. In an embodiment, the pH level is compared to at least one threshold. If the sensed pH level is above a first threshold, such as above a pH level of 6 for example, the controller **40** may be configured to determine that the heat exchanger **22** is in an acceptable condition. In such embodiments, the air conditioning system **20** will continue to operate normally.

However, if the sensed pH level is below the first threshold, the pH level may indicate that particulate matter has accumulated on the heat exchanger **22**. In such instances, the controller **40** may be configured to indicate a need for service. The indicator may be associated with a component of the air conditioning system **20** that is visible by a user. For example, the controller **40** may display a message on the thermostat that service of the air conditioning system **20**, and in some embodiments heat exchanger **22**, is required. In another embodiment, the controller **40** may operate an indicator associated with a component of the air conditioning system **20** that is typically visible by a service man during a maintenance operation. For example, the controller **40** may energize a light that indicates to the service man that maintenance of the heat exchanger **22** is required.

The controller **40** may alternatively or additionally be configured to either directly or indirectly place a request for service. In an embodiment, the controller **40** is able to communicate with a remote system, such as a cloud-based system (illustrated schematically at **46**) for example, the need for service. Based on the sensed pH level, the controller **40** will determine the urgency of the service. For example, if the sensed pH level is below a second threshold, the controller **40** may be configured to request immediate service of the air conditioning system **20**. The second threshold may correspond to instances when the air flow at the heat exchanger **22** is reduced by at least 50%. However, it should be understood that any suitable threshold is within the scope of the disclosure.

In embodiments where the sensed pH level is between the first threshold and the second threshold, the controller **40** may determine an approximate date by which service is required in the future. In an embodiment, the future service date is based on an estimation of when the pH level of the particulate matter will fall below the second threshold.

Alternatively, or in addition, a service man may be able to manually determine a condition of the heat exchanger **22** without actually seeing the heat exchanger **22**. In an embodiment, during a maintenance operation, a service man will measure the pH level of the condensate within the condensate drain pan **30** using a commercially available standard pH test strip, a pH meter, and/or a colorimeter. The service man will then compare the pH level indicated by the test strip to a correlated table, which will identify a condition of heat exchanger **22** and whether maintenance of the heat exchanger, specifically cleaning of the debris accumulated of the exterior of the heat exchanger **22**, is required. In an embodiment, the service man may perform maintenance in response to the condition of the heat exchanger **22**. However, in other embodiments, the table may indicate or suggest a future date by which maintenance of the heat exchanger **22** should be performed.

Monitoring of the pH level of the condensate of a heat exchanger **22**, such as an evaporator for example, provides a cost effective mechanism for accurately indicating the condition of the particulate matter accumulated on the evaporator. By actively identifying clogging, maintenance of the heat exchanger can be expedited, thereby minimizing the wear and tear on the remainder of the air conditioning system **20**, and reducing the operating costs of the air conditioning system **20**.

The term "about" is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

What is claimed is:

1. A method for evaluating a heat exchanger of an air conditioning system comprising:

measuring a pH level of a condensate of the heat exchanger via a sensor;

communicating the pH level of the condensate from the sensor to a controller;

comparing, via the controller, the pH level of the condensate measured by the sensor to a first threshold to evaluate a condition of the heat exchanger; and

in response to the pH level being less than the first threshold, determining that the heat exchanger has a flow blockage.

2. The method of claim **1**, further comprising operating an indicator in response to the pH level to indicate a need for service.

3. The method of claim **2**, wherein the indicator is associated with a thermostat of the air conditioning system.

4. The method of claim **1**, wherein the sensor is a pH sensor, and measuring the pH level of the condensate of the heat exchanger is performed automatically by a pH sensor.

5. The method of claim **4**, further comprising:

comparing the pH level to a second threshold in response to determining that the pH level is less than the first threshold.

6. The method of claim **5**, wherein in response to determining that the pH level is less than or equal to the second threshold, communicating with a remote system a need for immediate service.

7. The method of claim **5**, wherein in response to determining that the pH level is between the first threshold and the second threshold, estimating a date by which service will be required.

8. The method of claim **1**, wherein measuring the pH level of the condensate of the heat exchanger is performed manually.

9. The method of claim **8**, wherein measuring the pH level of the condensate is performed using one of a pH test strip, a pH meter, and a colorimeter.

10. The method of claim **8**, wherein determining the condition of the heat exchanger in response to the pH level further comprises comparing the pH level to a correlated table.

11. An air conditioning system comprising:

a heat exchanger;

a pH sensor operable to monitor a pH level of a condensate from the heat exchanger; and

a controller configured to:

receive the pH level of the condensate from the pH sensor; and

compare the pH level to at least one threshold; and

in response to determining that the pH level is less than the at least one threshold, determining that the heat exchanger has a flow blockage.

12. The air conditioning system of claim **11**, further comprising a condensate drain pan disposed vertically beneath the heat exchanger.

13. The air conditioning system of claim **12**, wherein the pH sensor is arranged within the condensate drain pan.

14. The air conditioning system of claim **11**, wherein the controller is further configured to operating an indicator in response to the pH level to indicate a need for service.

15. The air conditioning system of claim **11**, wherein the controller is further configured to communicate a need for immediate maintenance.

* * * * *