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(54) Title: ANTIMICROBIAL APPLICATION METHODS AND SYSTEMS WITH IMPROVED PH MONITORING

(57) Abstract: Methods and systems for determining the concentration, and hence pH, of an aqueous antimicrobial solution for treatment of food work pieces. The methods involve storing the original starting amount and concentration of water and acid of the antimicrobial solution, monitoring amounts of water and acid supplied to a system, storing an average of the volume of acid delivered per pump stroke, and calculating the strength of the solution based on the monitored amounts together with the average stroke volume of acid previously supplied to the system which are representative of the strength of recycled aqueous antimicrobial solution. Amounts of acid added the system can be automatically adjusted in real time to maintain a desired strength of the antimicrobial solution. The systems include modular flow meters and pumps that can be used to measure the inputs to the system, and which can be separately installed and maintained.

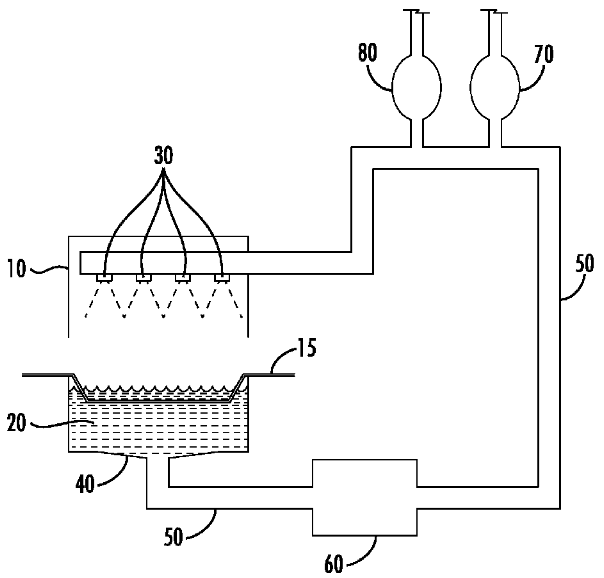

FIG. 1

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ANTIMICROBIAL APPLICATION METHODS AND SYSTEMS WITH IMPROVED PH MONITORING

BACKGROUND

[0001] Food work pieces are often treated with antimicrobial solutions to kill or control microbial populations that may otherwise deleteriously affect the food product. This disclosure relates to antimicrobial application methods and systems, and more particularly to a Peragonn antimicrobial application method and system with improved pH monitoring for use in connection with food work pieces and surfaces and other items associated with food processing.

[0002] Antimicrobial application systems, including spray cabinets are known in the art. The disclosures of U.S. Patent Nos. 6,742,720 and 9,072,315, together with U.S. patent application serial numbers 14/471,846, and 14/510,385 are incorporated herein by reference. These patents and applications discuss a number of antimicrobial application systems and highlight a number of the advantages and disadvantages of these systems. A suitable antimicrobial solution is peracetic acid, which is a water-based solution. One suitable antimicrobial solution is available under the name of Peragonn from Safe Foods Corporation of North Little Rock, Arkansas.

[0003] While antimicrobial solutions play an essential role in food safety by reducing or eliminating microbial populations, antimicrobial solutions may also include various levels of toxicity if excessive levels are consumed. A strong acid solution can furthermore discolor chicken carcasses, which is not esthetically appealing to consumers, plus it raises costs for the food producer. An acid solution which is too weak or at an incorrect pH may not be as effective as it should be, which could be dangerous to consumers. Thus, controlling microbial populations on food work pieces with antimicrobial solutions may require achieving a delicate balance between the desired control of the microbial populations and the strength, pH and residual presence of the antimicrobial components used to control the microbial levels.

[0004] The known methods and systems for applying antimicrobial solutions work well for many applications, but they are not without problems. The known application systems can incorporate a pH sensor for monitoring the pH level; however, in practice it has been found that pH sensors quickly stop working in a food production facility, as they can easily become clogged with fat or food particles. There may be also be a time lag before the pH sensor provides a result, which can delay correction of the pH of the antimicrobial solution to keep the pH within the target range. Furthermore, the pH sensors that are available for use in industrial processes may not be very accurate or may require frequent recalibration. The sensors are often temperature sensitive and may therefore give differing readings at different seasons or even at different times of the day. These issues can lead to significant down time of the processing equipment as the production line has to be stopped while pH sensors are recalibrated, cleaned, or repaired.

SUMMARY

[0005] In one aspect, this disclosure relates to methods and systems for determining the strength or pH of an aqueous antimicrobial solution for treatment of food work pieces. The food work pieces may include, for example, cut up chicken pieces, whole chicken carcasses, beef, veal, pork, fish, fruit, vegetables, tubers, legumes, other plants, other meats, and other food stuffs. The methods involve monitoring amounts of water and acid supplied to a system, and storing the starting volume and pH of the antimicrobial solution, and storing a running average of the volume of acid delivered per pump stroke, and calculating the strength of the solution based on the monitored original and added amounts of water and acid, together with the running average stroke volume of acid previously supplied to the system, which are representative of the strength of recycled aqueous antimicrobial solution. Amounts of acid added the system can be automatically adjusted in real time to maintain a desired strength of the antimicrobial solution. The systems include modular monitors that can be used to measure the inputs to the system, and which can be separately installed and maintained.

[0006] With the methods and systems described herein, a very accurate and real time calculation of the strength of the antimicrobial solution can be maintained, and the amounts of acid that are added into the system can be automatically adjusted in real time to keep the pH of the antimicrobial solution within the target range of a minimum and a maximum amount. This can be done without the need of a pH sensor to track the pH, and hence the strength, of the solution. It is found that embodiments of the algorithm to calculate the pH of the solution are more accurate, reliable, maintenance free, and real time than using pH sensors to directly monitor the pH. This thus avoids the need for costly pH sensors that can easily become clogged.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Embodiments of the present invention, as described herein by way of example, in conjunction with the following various features and characteristics of the non-limiting and non-exhaustive embodiments disclosed and described in this specification, may be better understood by reference to the accompanying Figures.

[0008] **FIG. 1** is a simplified view of an example of an antimicrobial treatment system for food work pieces;

[0009] **FIG. 2** is a schematic of a control panel for the system;

[0010] **FIG. 3** is a schematic of modular pumps and meters for use in the system;

[0011] **FIG. 4** is a view of the modular pumps and meters of FIG. 3 mounted on a central control board; and

[0012] **FIG. 5** is a flow chart of one embodiment of one method of the invention.

DESCRIPTION

[0013] Various embodiments of antimicrobial treatment systems and methods are described herein for treatment of food work pieces. Application of an antimicrobial treatment solution to treat the food product may include covering a treatment surface of the food product with the antimicrobial treatment solution comprising an acidic compound in solution. For example, the food product may treated by submerging, e.g., dipping, or antimicrobial treatment solution may be sprayed onto a surface of the food product to be treated with a saturating spray, as are known in the art. One example of an antimicrobial treatment systems including spray application is described in U.S. Patent No. 6,742,720, issued June 1, 2004, to Noland for SPRAY APPLICATION SYSTEM; U.S. Patent Application No. 14/471,846, filed August 28, 2014, titled APPLICATION SYSTEM AND RECYCLE AND RELATED USE OF ANTIMICROBIAL QUATERNARY AMMONIUM COMPOUND; and U.S. Patent Application No. 14/510,385, filed October 9, 2014, titled ANTIMICROBIAL APPLICATION SYSTEM

WITH RECYCLE AND CAPTURE, the contents of each are herein incorporated by reference in their entirety.

[0014] In the processing of food work pieces such as, for example, cut up chicken pieces, whole chicken carcasses, beef, veal, pork, fish, fruit, vegetables, tubers, legumes, other plants, other meats, and other food stuffs, an antimicrobial solution may be applied. It will be appreciated that particular application systems and methods, and types of antimicrobial solutions may be different for different food work pieces. For example, whole chicken carcasses may be attached to a hook conveyor for conveying through a spray cabinet, whereas cut chicken pieces may be placed on a conveyor belt for conveying through a dip tank. Other work pieces may be drenched with the antimicrobial solution. The invention is not intended to be limited to any particular application methods described herein, which are exemplary only.

[0015] A suitable antimicrobial solution may be an aqueous solution of peroxyacetic acid (also known as peracetic acid). One particular example of a suitable antimicrobial solution is Peragonn, available from Safe Foods Corporation, of North Little Rock, Arkansas, which is an aqueous solution of peroxyacetic acid, hydrogen peroxide and HEDP (1-hydroxyethane 1,1-diphosphonic acid). Peroxyacetic acid is generally used for chicken processing in a concentration of less than 220 PPM at a contact time from 55-65 seconds. These antimicrobial solutions are thus preferably applied to the food work pieces at a pH between about 2.0 and 1.0. It is an object of the present invention to automatically maintain the pH of the antimicrobial solution within the target range between the minimum and the maximum.

[0016] Other compounds, such as citric acid, acetic acid, hydrochloric acid, sulfuric acid, cetylpyridinium chloride, and many others, are also used in the processing of food work pieces, and the invention is not limited in this regard. It will be appreciated that each antimicrobial solution and food work piece involves the use of differing application methods, concentrations, and contact times, and that these can be varied to suit the application.

Figure 1, Treatment System

[0017] Referring first to Fig. 1, in the processing of chicken work pieces, a chicken carcass is first plucked, washed, cut into pieces and then put onto a conveyor belt. The chicken pieces travel into a dip tank 10 and pass through an antimicrobial solution 20. The antimicrobial solution 20 may be continually topped up in the tank from nozzles 30, or any suitable mechanism. The base of the dip tank 10 can include a recycling tank 40 into which the antimicrobial solution is pumped after having been initially filtered with a large mesh. The liquid from the recycling tank 40 is then passed via a conduit 50 to a sanitizer 60 where it is filtered and passes through a UV light sterilizer and is reused by being returned to the spray nozzles 30 and mixed with fresh antimicrobial solution.

[0018] Chicken pieces typically enter the dip tank 10 with water on them from the washing step that follows the plucking step. This water tends to come off the work pieces and be recycled into the recycling tank 40 along with the antimicrobial solution 20, which tends to dilute the acid antimicrobial solution. Also, as the chicken carcasses or work pieces are dipped or sprayed, some of the acid adheres to the carcass or piece itself and also to particles that fall from the carcasses and are filtered out. This additionally tends to dilute the acid solution.

[0019] It is desirable to continuously add varying quantities of acid and/or water to the antimicrobial solution as it is recycled so that it stays at an appropriate concentration, and hence pH. The water and acid antimicrobial solution are added via pumps 70 and 80 to a conduit 50 to create an aqueous antimicrobial solution 20 for application to food work pieces conveyed through the treatment system. The pumps are connected to a control system (not shown in Fig. 1). The aqueous antimicrobial solution that did not adhere to the food work pieces is recycled via recycling tank 40 and sanitizer 60, and the recycled antimicrobial solution is mixed with the fresh antimicrobial solution in conduit 50 for application to the food work pieces. It should be appreciated that the system shown and described in Fig. 1 is very simplified for ease of description, and in a real system there would be many more components such as pumps, mesh filters, sanitizers, and the like.

Figure 2, Control Panel

[0020] A schematic for a control panel for a system according to this disclosure is shown in Fig. 2. The control panel includes a processor 100, which may be connected to a power supply 110, an acid pump control 120, an acid flow meter 80, a water meter 70, a pressure transducer 130, and an alert light 140. Also connected may be a display 200, an ethernet connection 220 (or other connection to a network such as the Internet, or an intranet, or another telecommunication network or computer network), and an input device such as a keyboard. The network connection can include an internet connection so that secure access can be granted to the system from any location. This remote access can help with any system setup and trouble-shooting that needs to be conducted, as a person that is very knowledgeable about the system does not need to be located on site.

[0021] The method includes continuously monitoring the amounts of water and acid antimicrobial solution supplied to the system. For example, an exemplary system may have a steady water input between 5 and 10 gallons per minute. In one example system, the water input may be 7-8 gal/min, such as 7.3-7.5 gal/min.

[0022] The acid may be supplied at a variable rate of between 50 ml per minute and 100 ml per minute, such as 70-80 ml/min. To supply at a rate of 74.1 ml/min, for example, an acid pump delivering an average of 1.00 ml/stroke at 45 strokes/min at a pressure of 61.3 PSI may be used. In the methods and systems described herein, the amount of acid supplied by the acid pump per stroke can be continuously varied by the control system, in order to maintain the strength of the antimicrobial solution within a desired concentration range.

The pH Monitoring and Control Algorithm

[0023] In the memory of processor 100 a selected set of acid antimicrobial solution amounts supplied to the system over a predetermined time period may be stored. For example, the volume of the last 50 strokes of the acid pump may be stored, or the system may be set to store amounts of acid added to the system over a set period of time, such as the amount added over a value selected between 1 and 10 minutes. By storing, for example, the volume of the last 50 strokes of the acid pump, a running average of the amount of acid added to the system can be calculated. The processor 100 may store the total amount of acid used in gallons along with the average acid rate in ml/min The processor 100 may also store the water flow rate (in gal/min), which typically does not change during operation of the system, along with a running total of the amount of water used in gallons. The acid injection pressure may also be monitored. The processor 100 thus stores and can display data which is representative of amounts of water and acid antimicrobial solution present in the aqueous antimicrobial solution that is being applied to the food work pieces.

[0024] The processor 100 can calculate a strength in PPM ("parts per million") of the mixed fresh (i.e,. newly added) and recycled aqueous antimicrobial solution using the running average of the amounts of said water and acid antimicrobial solution supplied and the original starting amount and concentration (pH) of the antimicrobial solution. For example, the processor uses these values to calculate a ratio or the quantity of acid in PPM compared to the water, which indicates the pH. The processor can then adjust in real-time the amount of acid antimicrobial solution supplied to the system per stroke of the pump based on the calculated strength of the acid in PPM, to maintain a desired strength of said aqueous antimicrobial solution.

[0025] In order to vary the amount of acid supplied by the acid pump 80, the acid pump volume put out per stroke can be initially set as a percentage of its maximum stroke volume. The starting pump volume is typically set at 50% of the maximum stroke volume. This variation in stroke volume may be achieved by any suitable means, for example, the control system can vary the length of time that a filling valve to the pump is opened.

[0026] The pump 80 can be periodically calibrated while the system is in an idle mode by setting the pump to stroke 100 times and measuring the total mL of acid that is pumped out. The starting mL/stroke volume can then be calculated. Setting the pump to initially pump out only 50% of its maximum stroke volume means that the amount of acid pumped out can be easily adjusted up or down by the processor 100 by adjusting the length of time a control signal to the pump is sent for, or by any other means.

[0027] The pumps can include Dulcometer flow meters. A Dulcometer is an acid flow meter that is commercially available, for example, from ProMinent, Inc. Different Dulcometer models can be employed for different modular flow rates – for example, the rate of acid antimicrobial solution entering the system is much lower than the rate of flow of the fresh water, or the aqueous acid and water mixture that is recycled from the capture system, and the meter that is chosen is sized accordingly. The pumps and monitors are installed on-site, as they are specific to the site installation.

[0028] The flow meters generate a number of frequency pulses per gallon or other unit of fluid flowing through them. This number is known as the K-factor, and it is generally calculated during production of the flow meter. The K-factor values for each flow meter are stored in the memory of the processor 100 to enable the processor to monitor the amount of fluid flowing through the meter based up on the meter signals that are generated.

[0029] To start the system, a user first opens the water valve so that the system is at the desired water flow rate. The system can monitor the water flow rate using a suitable flow meter for accuracy. Then the user checks that no alert conditions are active prior to opening the acid valve to the desired flow rate. Once the pump has stroked 50 times after startup in this example, it can start to automatically adjust the mL/stroke of the acid that is dispensed. The system is then running, and the food work pieces can be introduced into the system for cleaning.

[0030] The concentration of peracetic acid can periodically be titrated and manually checked to confirm that the calculated concentration of the solution is correct. A 100 mL specimen cup can be used for the titration procedure. Depending upon the calculated PPM of the solution, the following amounts of solution are placed in the specimen cup: for 0 to 200 PPM, 30ml is added, for 201-500 PPM, 5 ml is added, and for 501 to 1000 PPM, 2.5 ml is added. 10 drops of sulfuric acid 50% are then added to the cup and the mixture is swirled for 5 seconds. One drop of potassium iodide is added, and again the mixture is swirled for 5 seconds. Five drops of starch indicator are added, and the mixture swirled for 5 seconds. The mixture will turn black at this point. To test, the user adds 1 drop of Peracetic DT at a time, and swirls the mixture to mix. The number of drops added until the sample turns clear is counted, provided that the mixture stays clear after 10 seconds. If it does not stay clear, another drop of Peracetic DT is needed. The number of drops used is multiplied by the PPM number based on the size of the sample used: 30 ml sample, 1 drop = 5PPM; 5 ml sample, 1 drop = 30 PPM; or 2.5ml sample, 1 drop = 60 PPM. This method tests that the reading is in the expected range.

Figure 5, The Algorithm Flow Chart

[0031] Fig. 5 is a flow chart of one embodiment of one method of the invention. The flow chart shows a method of automatically maintaining the proper pH of a solution in an apparatus for treatment of food work pieces, comprising: (a) storing 501 in a processor memory the initial amounts of water, and acid antimicrobial solution, and pH of the combined water and acid antimicrobial solution, and the desired strength or pH of the mixed water and aqueous antimicrobial solution; (b) supplying 502 water and an acid antimicrobial solution to a treatment system, the water being supplied by a first pump as needed to maintain the required volume of water in the system, and the acid antimicrobial solution being supplied by a second pump which is variable; (c) mixing **503** by the system said water and acid antimicrobial solution to create an aqueous antimicrobial solution for application to food work pieces conveyed through the treatment system; (d) monitoring **504** the amounts of the water with a water flow meter and the acid antimicrobial solution with an acid flow meter as the water and the acid are supplied to the system; (e) storing **505** in a processor memory a selected set of acid antimicrobial solution amounts added to the system per pump stroke of said acid pump or time period; (f) calculating

506 in a processor an amount of said acid antimicrobial solution added to the system during said selected set of amounts; (g) calculating **507** in a processor a strength of said aqueous antimicrobial solution using the calculated amount of said acid antimicrobial solution pumped into the system together with the monitored amount of water supplied to the system; (h) adjusting **508** by the processor in real-time the amount of acid antimicrobial solution supplied to the system per pump stroke or time period compared to the amount of water supplied to the system to maintain a desired strength of said aqueous antimicrobial solution; and

(i) collecting **509** data automatically by the processor from the meters, and controlling the pumps. The flow chart shows the embodiment further comprising:

communicating **510** by the processor through a network to a remote device, and transmitting by the processor the collected data to the remote device, and receiving by the processor control instructions for the pumps from the remote device. The method is initialized in step **501** at the beginning of an operated period, and then steps 502-510 are each run as needed, either sequentially, simultaneously, or independently.

Figures 3 and 4, the Modular Control System

[0032] Each pump and thus fluid input to the system can be separately monitored and controlled, which means that the system can be built in a modular manner, and that a single bulky monitoring system does not need to be installed on-site. The fluid output from the system can also be monitored. For example, the difference between the amount of fluid being added to the system and the amount of fluid being recycled provides an indication of the amount of fluid that is leaving the system attached to the food work pieces. All of the pumps and monitors can be supplied as separate modules.

[0033] Figs. 3 and 4 show four pump and flow meter modules 300 being mounted on a control board 310. The modules 300 are lighter and easier to install into a food processing factory than current pH monitoring systems.

[0034] A pump and flow meter module 300 is shown comprising of a substrate 320, a flow meter 330 for monitoring and measuring the volume of a liquid pumped by a pump, the flow meter attached to the substrate, and a mounting bracket 330 attached to the substrate, the bracket adapted to mount a pump (not shown) to the substrate, wherein the flow meter is one of the group consisting of a water flow meter and an acid flow meter.

[0035] The module 300 may further comprise a pump (not shown) mounted to the bracket 330, the pump being one of the group consisting of a water pump and a variable acid pump, wherein the flow meter is a water flow meter if the pump is a water pump, and the flow meter is a acid flow meter if the pump is an acid pump; at the least one tube 340 connecting the meter to the pump; and fittings 350 adapted to connect the module to tubes connecting the meter and the pump to a antimicrobial application system.

[0036] The module 300 may further comprise a control board 310, which is larger than the substrate, to which the substrate 320 is attached; and at least one additional such module 300, wherein the substrate of each additional module is also attached to the control board. The modules 300 may have substrates that are made of a material of the group consisting of: plywood, wood, sheet metal and plastic, and wherein the control board is made of a material of the group consisting of: plywood, wood, sheet metal, plastic, wall, and a food processing machine.

[0037] The modules 300 can be placed along different parts of the processing line for ease of installation, and do not need to be located together on a single control board 310. For example, some of the water entering the system is at a washing step for the food work pieces, and a water flow meter may be installed at that point in addition to a water flow meter being installed for the spray cabinet for the antimicrobial solution. Consequently, the modular monitors are much more flexible as to the factory floor space that needs to be taken up than with present systems, and thus retro-fitting of existing factories is simple to complete.

OTHER MATTERS

[0038] The present invention is not limited in its application to the details of construction and the arrangement of components set forth in the description or illustrated in the drawings herein. The invention is capable of other embodiments and of being practiced in various ways.

[0039] Other modifications, changes and substitutions are intended in the foregoing, and in some instances, some features will be employed without a corresponding use of other features. For example, the different features of the alternate embodiments may be merged or combined in any number of different combinations. Also, the antimicrobial application unit may take any number of forms, shapes, and sizes and need not be one of the spray cabinet embodiments disclosed in U.S. Patent No. 6,742,720. Similarly, any number of different compositions or solutions or antimicrobial solutions may be used in any number of different concentrations, and the compositions or solutions may or may not include one or more antimicrobials.

[0040] Further still, additional pumps, filters, and similar components may be incorporated into the system. Also, any number of different methods may be used to monitor the composition of the solution in the conduit 50. Accordingly, it is appropriate that the invention be construed broadly and in a manner consistent with the scope of the invention disclosed.

[0041] This disclosure describes various elements, features, aspects, and advantages of various embodiments antimicrobial solutions, concentrated solutions, methods of making and formulating such solutions, and methods of treating food work pieces with such solutions. It is to be understood that certain descriptions of the various embodiments have been simplified to illustrate only those elements, features and aspects that are relevant to a more clear understanding of the disclosed embodiments, while eliminating, for purposes of brevity or clarity, other elements, features and aspects. The present disclosure is not intended to be limited by the percent composition of the examples unless claimed otherwise. Percent compositions are to be understood as being by weight unless specified otherwise.

[0042] All numerical quantities stated herein are approximate unless stated otherwise, meaning that the term "about" or "approximately" may be inferred when not expressly stated. The numerical quantities disclosed herein may be nominal numerical quantities and are to be understood as not being strictly limited to the exact numerical values recited. Instead, unless stated otherwise, each numerical value is intended to mean both the recited value and a functionally, for example pharmaceutically, equivalent range surrounding that value. All numerical ranges stated herein include all sub-ranges subsumed therein. For example, a range of approximately or about 1 to 10 is intended to include all sub-ranges between and including the recited minimum value of 1 and the recited maximum value of 10. Any maximum numerical limitation recited herein is intended to include all lower numerical limitations. Any minimum numerical limitation recited herein is intended to include all higher numerical limitations. Additionally, in some illustrative embodiments, quantities or ranges may be given. It is to be understood that any such quantity or range is provided as an illustrative example or instance of an embodiment and is not intended to limit that or other embodiments.

[0043] For instance, an existing in-memory database may be converted to a memory-mapped database consistent with embodiments of the present invention. Such a conversion may include the provision of secondary storage for a data repository and the programming of modules, such as a fault handler for the data repository. As is common in the profession, "memory" often refers to volatile solid-state memory, sometimes earlier referred to as random access memory or RAM. Disks are non-volatile storage or secondary storage, and are a type of machine readable memory medium.

[0044] It will be apparent to one of ordinary skill in the art that some of the embodiments as described hereinabove may be implemented in many different embodiments of software, firmware, and hardware in the entities illustrated in the figures. The actual software code or specialized control hardware used to implement some of the present embodiments do not limit the present invention.

[0045] As used herein, a "processor" or a "computer" or a "computer system" may be, for example and without limitation, either alone or in combination, a personal computer (PC), server-based computer, main frame, server, microcomputer, minicomputer, laptop, personal data assistant (PDA), cellular phone, pager, processor, including wireless and/or wireline varieties thereof, and/or any other computerized device capable of configuration for receiving, storing and/or processing data for standalone application and/or over a networked medium or media.

[0046] Processors, computers and computer systems described herein may include operatively associated computer-readable memory media such as memory for storing software applications and instructions used in obtaining, processing, storing and/or communicating data. It can be appreciated that such memory can be internal, external, remote or local with respect to its operatively associated computer or computer system. Memory may also include any means for storing software or other instructions including, for example and without limitation, a hard disk, an optical disk, floppy disk, DVD, compact disc, memory stick, ROM (read only memory), RAM (random access memory), PROM (programmable ROM), EEPROM (extended erasable PROM), and/or other like computer-readable media.

[0047] In general, computer-readable memory media may include any memory medium capable of being a memory for electronic data representative of data or computer instructions stored, communicated or processed in accordance with embodiments of the present invention. Where applicable, method steps described herein may be embodied or executed as computer instructions stored on a computer-readable memory medium or media.

[0048] It can be appreciated that, in certain aspects of the present invention, a single component may be replaced by multiple components, and multiple components may be replaced by a single component, to provide an element or structure or to perform a given function or functions. Except where such substitution would not be operative to practice certain embodiments of the present invention, such substitution is considered within the scope of the present invention.

CLAIMS

1. A method of automatically maintaining the proper pH of a solution in an apparatus for treatment of food work pieces, comprising:

(a) storing in a processor memory the initial amounts of water, and acid antimicrobial solution, and pH of the combined water and acid antimicrobial solution, and the desired strength or pH of the mixed water and aqueous antimicrobial solution;

(b) supplying water and an acid antimicrobial solution to a treatment system, the water being supplied by a first pump as needed to maintain the required volume of water in the system, and the acid antimicrobial solution being supplied by a second pump which is variable;

(c) mixing by the system said water and acid antimicrobial solution to create an aqueous antimicrobial solution for application to food work pieces conveyed through the treatment system;

(d) monitoring the amounts of the water with a water flow meter and the acid antimicrobial solution with an acid flow meter as the water and the acid are supplied to the system;

(e) storing in a processor memory a selected set of acid antimicrobial solution amounts added to the system per pump stroke of said acid pump or time period;

(f) calculating in a processor an amount of said acid antimicrobial solution added to the system during said selected set of amounts;

(g) calculating in a processor a strength of said aqueous antimicrobial solution using the calculated amount of said acid antimicrobial solution pumped into the system together with the monitored amount of water supplied to the system;

(h) adjusting by the processor in real-time the amount of acid antimicrobial solution supplied to the system per pump stroke or time period compared to the amount of water supplied to the system to maintain a desired strength of said aqueous antimicrobial solution; and

(i) collecting data automatically by the processor from the meters, and controlling the pumps.

2. The method in claim 1, further comprising:

communicating by the processor through a network to a remote device, and transmitting by the processor the collected data to the remote device, and receiving by the processor control instructions for the pumps from the remote device.

3. The method according to claim 2, wherein the calculated amount of said acid antimicrobial solution is an average of the amount of acid antimicrobial solution delivered per pump stroke.

4. The method according to claim 3, wherein the calculated average amount of said acid antimicrobial solution is a running average of the prior 50 pump strokes.

5. The method according to claim 4, wherein said running average of the prior 50 pump strokes is recalculated with each pump stroke of said acid pump.

6. The method according to claim 4, wherein said running average is stored in said processor memory.

7. The method according to claim 1, wherein the calculated amount of said acid antimicrobial solution is a total of the amount of acid antimicrobial solution delivered per set of pump strokes.

8. The method according to claim 1, further comprising:

recycling at least a portion of the aqueous antimicrobial solution;

monitoring an amount of the aqueous antimicrobial solution that is recycled; and

calculating the strength of the aqueous antimicrobial solution in the system using the monitored amount of recycled aqueous antimicrobial solution.

9. The method according to claim 1, further comprising:

monitoring an amount of water used in washing said food work pieces prior to the food work pieces entering said treatment;

calculating an amount of said water that remains on said food work pieces; and

calculating the strength of the aqueous antimicrobial solution in the system using the calculated amount of water entering the treatment system on said food work pieces.

10. The method according to claim 1, further comprising:

monitoring an amount of the food work pieces that pass through the treatment system;

calculating an amount of aqueous antimicrobial solution that remains on said food work pieces; and

calculating the strength of the aqueous antimicrobial solution in the system using the calculated amount of aqueous antimicrobial solution leaving the treatment system on said food work pieces.

11. The method according to claim 1, further comprising:

setting an initial stroke volume of said acid pump at 50% of its maximum stroke volume; and

adjusting the stroke volume up or down to adjust the amount of acid supplied to the system.

12. The method according to claim 1, wherein the aqueous antimicrobial solution is retained in a reservoir into which the food work pieces are passed, the method further comprising:

monitoring a level of aqueous antimicrobial solution in the reservoir, and calculating how much aqueous antimicrobial solution is present in the treatment system.

13. A system for treatment of food work pieces comprising:

a food work piece conveyor,

at least one pump and at least one flow meter for supplying and monitoring water to the treatment system;

at least one flow meter for monitoring and one variable pump for supplying an acid antimicrobial solution to the treatment system, and mixing said acid antimicrobial solution into the water to create an aqueous antimicrobial solution;

a processor including a memory to store a selected set of acid antimicrobial solution amounts supplied to the system by the variable pump, and the water flow rate, representing amounts of water and acid antimicrobial solution present in the treatment system; and

a control system adapted to use the processor to adjust in real-time the amount of acid antimicrobial solution supplied to the system by said variable pump compared to the amount of water supplied to the system to maintain a desired strength of said aqueous antimicrobial solution.

14. The system according to claim 13, wherein the water pump and flow meter are configured as a first modular component, and the acid variable pump and flow meter are configured as a second modular component, wherein the first and second modular components are configured for separate installation at variable locations in said treatment system.

15. The system according to claim 13, further comprising:

a recycling system to recycle an amount of aqueous antimicrobial solution, said recycling system including a pump and a flow meter configured as a third modular component for monitoring the flow of recycled aqueous antimicrobial solution.

16. The system according to claim 13, further comprising:

a reservoir for receiving said aqueous antimicrobial solution and into which the food work pieces are passed; and

a monitor for monitoring a level of aqueous antimicrobial solution in the reservoir.

17. The system according to claim 13, further comprising:

an application mechanism for applying the aqueous antimicrobial solution onto said food work pieces.

18. A control system for a food treatment system comprising:

a processor having a memory;

at least one flow meter monitoring an aqueous fluid input to the treatment system;

at least one variable pump supplying an acid antimicrobial solution for mixing into the aqueous fluid supplied to the treatment system, the processor storing a selected set of pumped acid amounts in its memory; and

a control mechanism for the acid antimicrobial solution pump, the control mechanism varying a volume of the pump stroke based on a strength of the mixed aqueous and acid antimicrobial solution calculated in said processor using said monitored aqueous fluid flow rate and said stored set of pumped acid amounts in order to maintain a desired concentration of said acid antimicrobial solution in said aqueous fluid.

19. The control system according to claim 18, wherein the at least one flow meter for monitoring aqueous fluid input to the treatment system is provided as a modular part.

20. The control system according to claim 18, wherein the at least one pump and its control mechanism are provided as a modular part.

21. The control system according to claim 18, wherein said least one said flow meter monitors an amount of water added to the treatment system.

22. The control system according to claim 18 comprising:

a monitor for measuring an amount of aqueous antimicrobial solution remaining in or recycled back to the treatment system.

23. A pump and flow meter module comprising:

(a) a substrate,

(b) a flow meter for monitoring and measuring the volume of a liquid pumped by a pump, the flow meter attached to the substrate, and

(c) a mounting bracket attached to the substrate, the bracket adapted to mount a pump to the substrate wherein the flow meter is one of the group consisting of a water flow meter and acid flow meter.

24. The module in claim 23, further comprising:

(a) a pump mounted to the bracket, the pump being one of the group consisting of a water pump and a variable acid pump;

(b) wherein the flow meter is a water flow meter if the pump is a water pump, and the flow meter is a acid flow meter if the pump is an acid pump;

(c) at the least one tube connecting the meter to the pump; and

(d) fittings adapted to connect the module to tubes connecting the meter and the pump to a antimicrobial application system.

25. The module in claim 23, further comprising:

(a) a control board, which is larger than the substrate, to which the substrate of claim 23 is attached; and

(b) at least one additional such module of claim 23, wherein the substrate of each additional module is also attached to the control board;

26. The module in claim 25:

(a) wherein the substrates are made of a material of the group consisting of: plywood, wood, sheet metal and plastic; and

(b) wherein the control board is made of a material of the group consisting of: plywood, wood, sheet metal, plastic, wall, and a food processing machine.

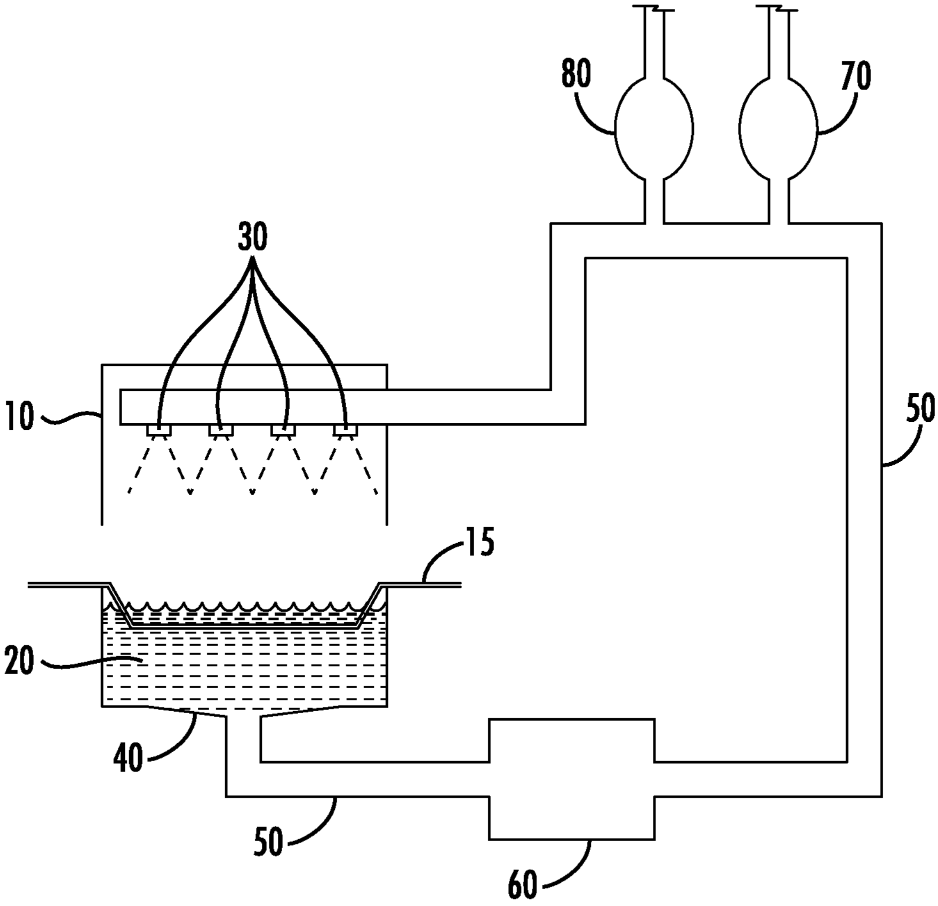

FIG. 1

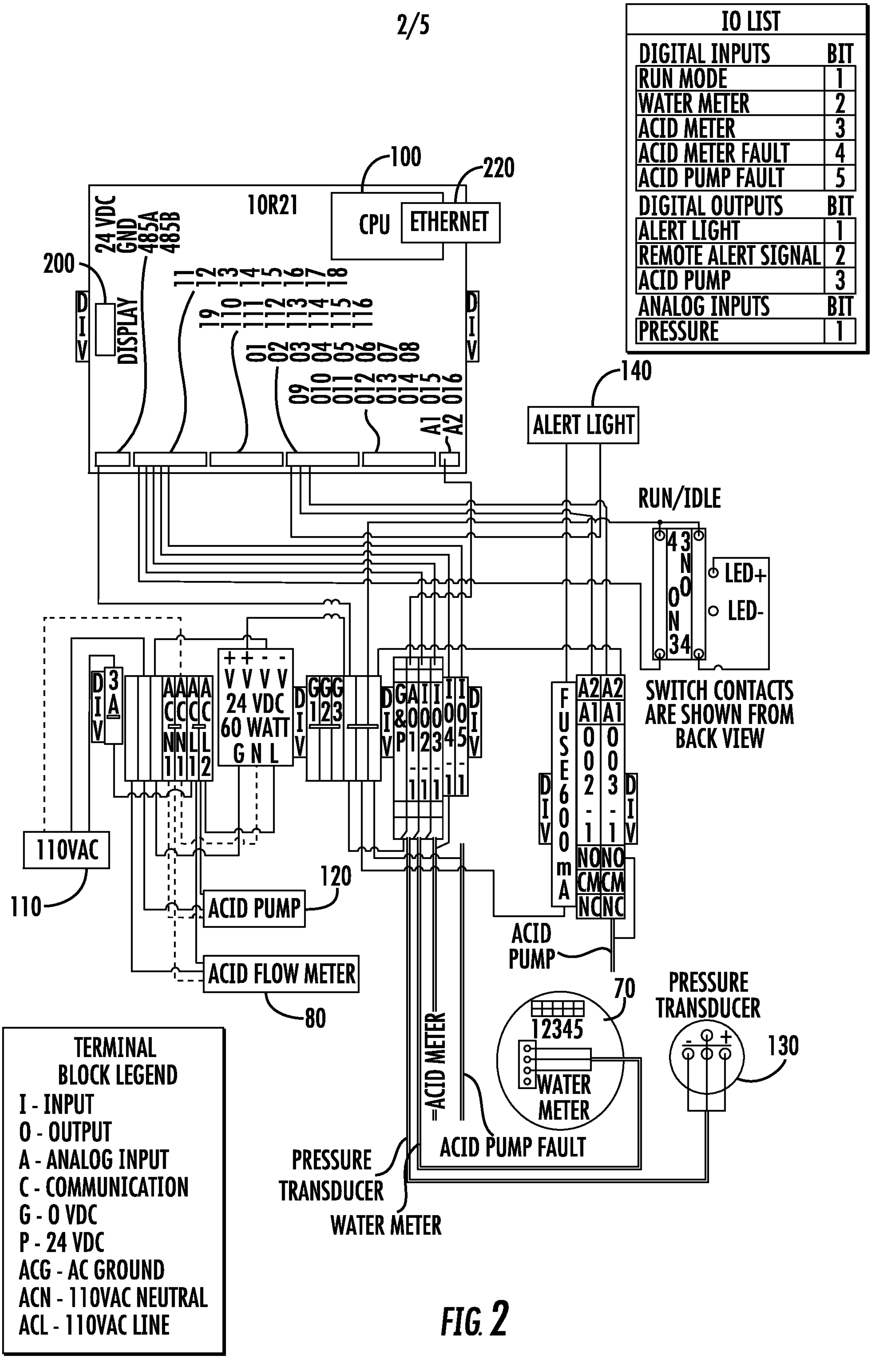
IO LIST
DIGITAL INPUTS BIT
RUN MODE 1
WATER METER 2
ACID METER 3
ACID METER FAULT 4
ACID PUMP FAULT 5
DIGITAL OUTPUTS BIT
ALERT LIGHT 1
REMOTE ALERT SIGNAL 2
ACID PUMP 3
ANALOG INPUTS BIT
PRESSURE 1
100
220
10R21
CPU
ETHERNET
24 VDC
GND
485A
485B
200
DISPLAY
DIV
I1 I2 I3 I4 I5 I6 I7 I8
I9 I10 I11 I12 I13 I14 I15 I16
O1 O2 O3 O4 O5 O6 O7 O8
O9 O10 O11 O12 O13 O14 O15 O16
A1 A2
140
ALERT LIGHT
RUN/IDLE
LED+
LED-
SWITCH CONTACTS ARE SHOWN FROM BACK VIEW
3A
ACN1 ACN1 ACL1 ACL2
++--
VVVV
24 VDC
60 WATT
G N L
GGG
123
G&P
AI0 1
AI0 2
AI0 3
AI0 4
AI0 5
FUSE 600mA
A2 A1 O O2-1
A2 A1 O O3-1
NO CM NC
110VAC
110
120
ACID PUMP
ACID FLOW METER
80
ACID PUMP
70
12345
WATER METER
PRESSURE TRANSDUCER
130
ACID METER
ACID PUMP FAULT
PRESSURE TRANSDUCER
WATER METER
TERMINAL BLOCK LEGEND
I - INPUT
O - OUTPUT
A - ANALOG INPUT
C - COMMUNICATION
G - O VDC
P - 24 VDC
ACG - AC GROUND
ACN - 110VAC NEUTRAL
ACL - 110VAC LINE

FIG. 2

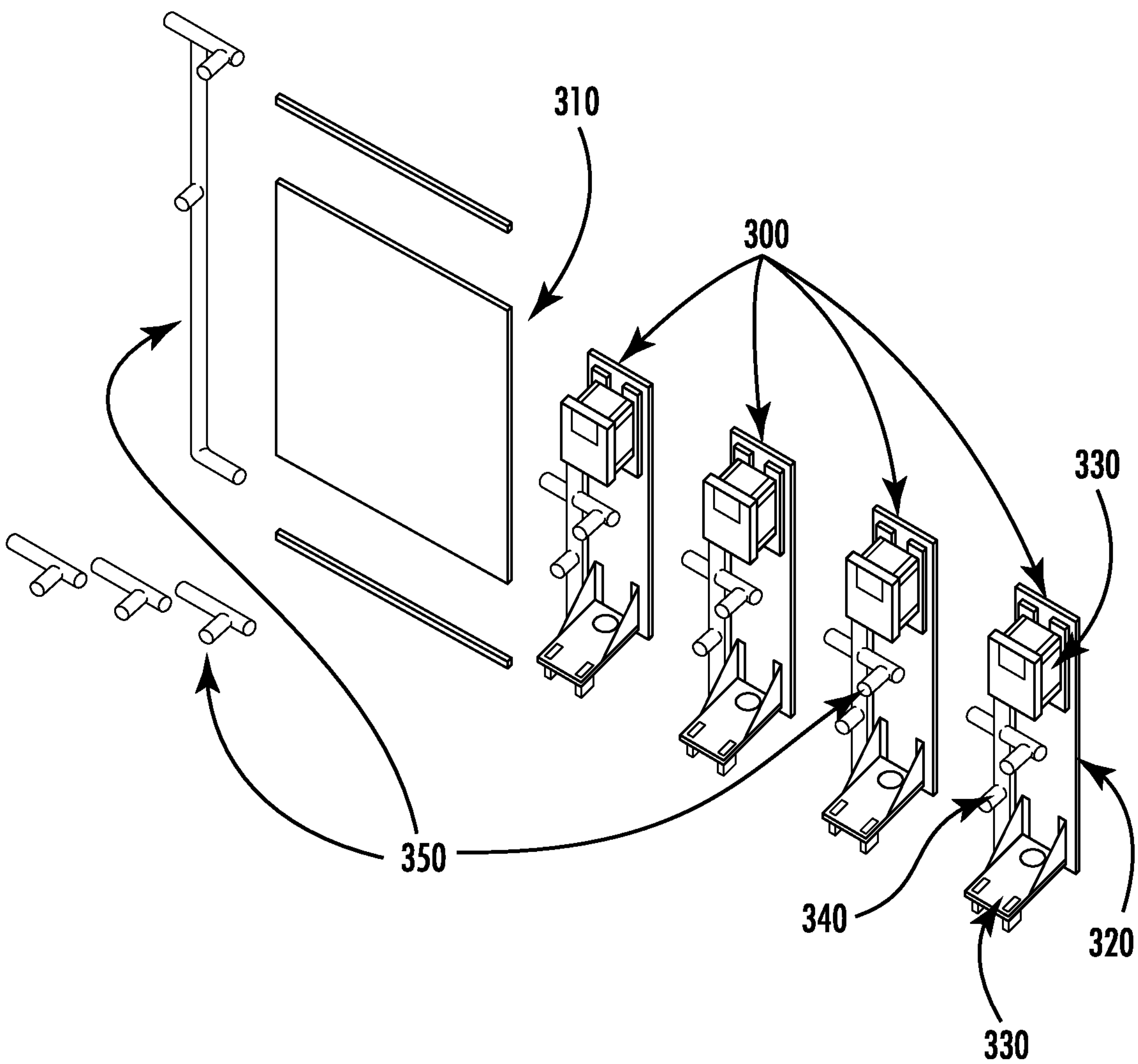

FIG. 3

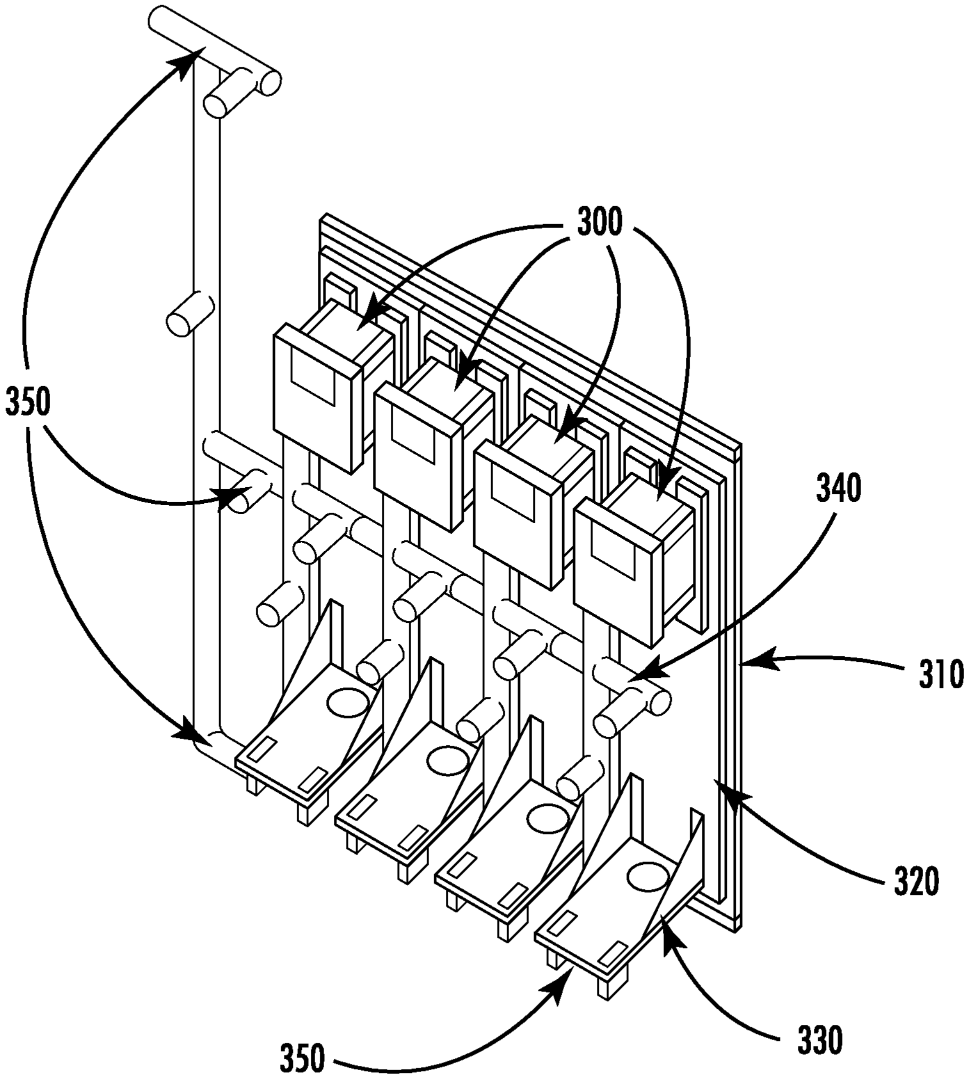

FIG. 4

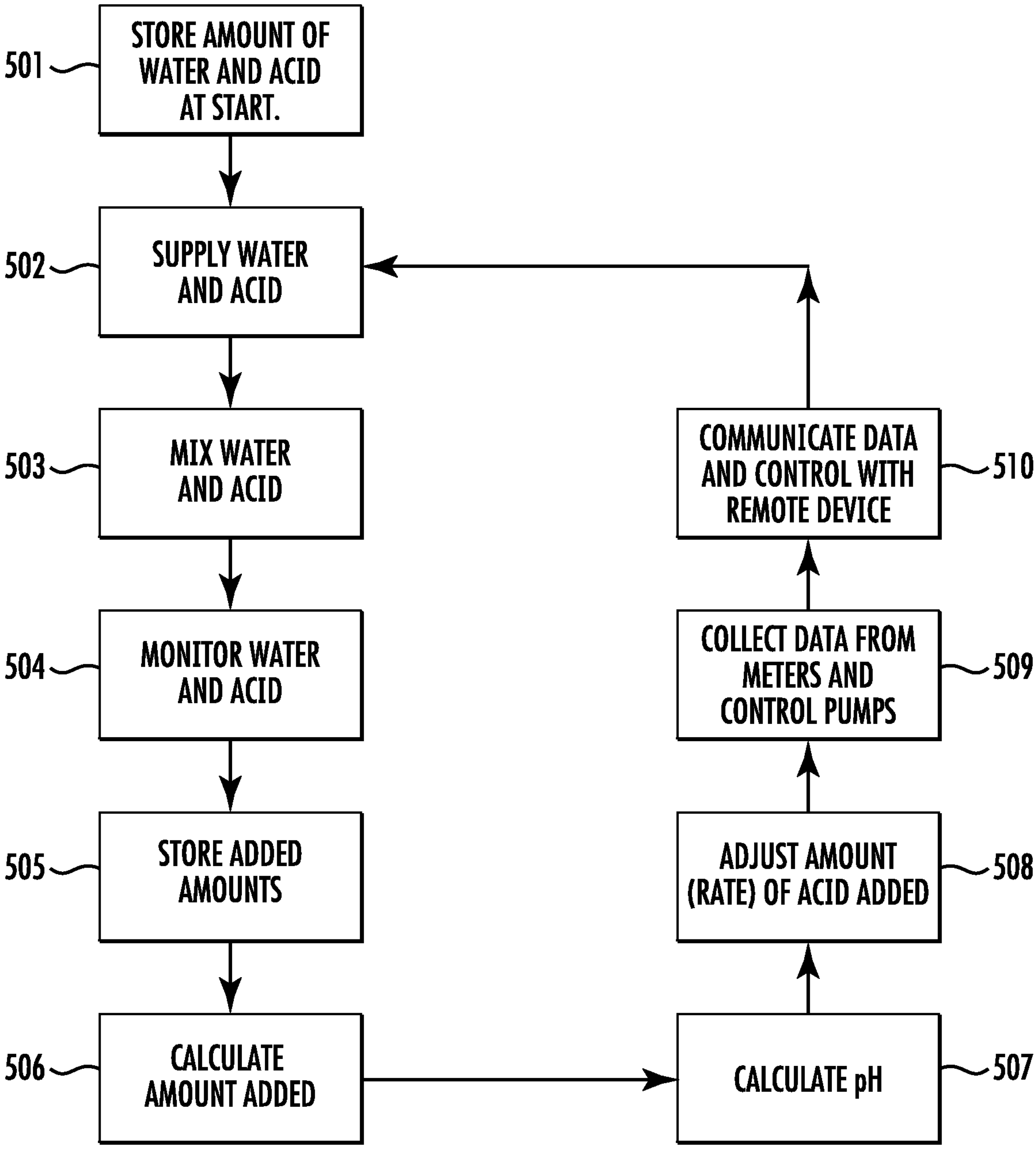
STORE AMOUNT OF WATER AND ACID AT START.
501
SUPPLY WATER AND ACID
502
MIX WATER AND ACID
503
MONITOR WATER AND ACID
504
STORE ADDED AMOUNTS
505
CALCULATE AMOUNT ADDED
506
CALCULATE pH
507
ADJUST AMOUNT (RATE) OF ACID ADDED
508
COLLECT DATA FROM METERS AND CONTROL PUMPS
509
COMMUNICATE DATA AND CONTROL WITH REMOTE DEVICE
510

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/29118

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-12 and 23-26, drawn to a method of automatically maintaining the proper pH of a solution for treatment of food work pieces and a pump and flow meter module.

Group II: Claims 13-22, drawn to systems for treatment of food work pieces.

-- Please See Supplemental Box --

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 16/29118

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A23L 3/3589, C02F 1/66, F04B 13/02, F04B 49/12, G01N 21/80, G05D 7/06, G05D 21/02 (2016.01)
CPC - A23L 3/3589, C02F 1/66, F04B 13/02, F04B 49/12, G01N 21/80, G05D 7/06, G05D 21/02

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)
IPC(8)- A23L 3/3589, C02F 1/66, F04B 13/02, F04B 49/12, G01N 21/80, G05D 7/06, G05D 21/02 (2016.01);
CPC- A23L 3/3589, C02F 1/66, F04B 13/02, F04B 49/12, G01N 21/80, G05D 7/06, G05D 21/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC- F04B 2201/0207, G01N 27/4165, G01N 2223/618, G05D 7/0623, G05D 11/139; USPC- 137/565.11, 137/625.3, 210/724, 210/739, 210/743, 210/749, 417/211.5, 417/470, 422/28, 422/110, 422/116, 426/335, 700/266, 700/267, 700/281, 700/282

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Pub West (US EP JP WO), Pat Base (AU BE BR CA CH CN DE DK EP ES FI FR GB IN JP KR SE TH TW US WO), Google Patent, Google Scholar, Google Web, FPO; search terms: treat, sterilize, sanitize, disinfect, purify, clean, antimicrobial, antibacterial, biocide, microbe, monitor, sense, measure, control, pH, food, pump, stroke, volume, meter, cycle, flow...

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y -- A	US 3,834,839 A (KREBS et al.) 10 September 1974 (10.09.1974), Figs. 1, 3, 8; col 1, ln 3-13; col 1, ln 57 to col 2, ln 10; col 2, ln 60-68; col 3, ln 53-65; col 4, ln 7-66	23-26 --------- 1-22
Y -- A	US 5,595,201 A (DOBREZ et al.) 21 January 1997 (21.01.1997), Fig. 1; col 1, ln 16-25; col 1, ln 53 to col 2, ln 2; col 2, ln 35-58; col 3, ln 4-28; col 4, ln 20 to col 5, ln 4; col 6, ln 8-40	23-26 --------- 1-22
A	US 2014/0305881 A1 (ALARID et al.) 16 October 2014 (16.10.2014), para [0005], [0033], [0036]-[0043], [0047], [0050], [0053], [0076]	1-22
A	US 2009/0035189 A1 (WU et al.) 05 February 2009 (05.02.2009), para [0005], [0064]	1-22
A	US 2004/0102380 A1 (FULTON et al.) 27 May 2004 (27.05.2004), para [0021]-[0023], [0057], [0058]	1-22

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "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)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "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
- "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
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 August 2016	02 SEP 2016

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

----Continued from Box No. III, Observations where unity of invention is lacking,----

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features

Groups II do not require a method of automatically maintaining the proper pH of a solution in an apparatus for treatment of food work pieces, comprising:
(a) storing in a processor memory the initial amounts of water, and acid antimicrobial solution, and pH of the combined water and acid antimicrobial solution, and the desired strength or pH of the mixed water and aqueous antimicrobial solution;
(b) supplying water and an acid antimicrobial solution to a treatment system, the water being supplied by a first pump as needed to maintain the required volume of water in the system, and the acid antimicrobial solution being supplied by a second pump which is variable;
(c) ... an aqueous antimicrobial solution for application to food work pieces conveyed through the treatment system;
(d) monitoring the amounts of the water with a water flow meter and the acid antimicrobial solution with an acid flow meter as the water and the acid are supplied to the system;
(e) storing in a processor memory a selected set of acid antimicrobial solution amounts added to the system per pump stroke of said acid pump or time period;
(f) calculating in a processor an amount of said acid antimicrobial solution added to the system during said selected set of amounts;
(g) calculating in a processor a strength of said aqueous antimicrobial solution using the calculated amount of said acid antimicrobial solution pumped into the system together with the monitored amount of water supplied to the system;
(h) adjusting by the processor in real-time the amount of acid antimicrobial solution supplied to the system per pump stroke or time period compared to the amount of water supplied to the system to maintain a desired strength of said aqueous antimicrobial solution; and
(i) collecting data automatically by the processor from the meters, and
controlling the pumps;
and
a pump and flow meter module comprising:
(a) a substrate,
(c) a mounting bracket attached to the substrate, the bracket adapted to mount a pump to the substrate wherein the flow meter is one of the group consisting of a water flow meter and acid flow meter, as required by Group I.

Groups I do not require a system for treatment of food work pieces comprising:
a food work piece conveyor;
a processor including a memory to store a selected set of acid antimicrobial solution amounts supplied to the system by the variable pump, and the water flow rate, representing amounts of water and acid antimicrobial solution present in the treatment system; and
a control system adapted to use the processor to adjust in real-time;
and
a control system for a food treatment system comprising:
a processor having a memory;
at least one flow meter monitoring an aqueous fluid input to the treatment system;
at least one variable pump supplying an acid antimicrobial solution for mixing into the aqueous fluid supplied to the treatment system, the processor storing a selected set of pumped acid amounts in its memory; and
a control mechanism for the acid antimicrobial solution pump, the control mechanism varying a volume of the pump stroke based on a strength of the mixed aqueous and acid antimicrobial solution calculated in said processor using said monitored aqueous fluid flow rate and said stored set of pumped acid amounts in order to maintain a desired concentration of said acid antimicrobial solution in said aqueous fluid, as required by Group II.

Shared Common Features

The only feature shared by Groups I and II that would otherwise unify the groups is treatment of food work pieces with apparatus, comprising: a processor including a memory; a pump and a flow meter for supplying and monitoring water to the treatment system water, and acid antimicrobial solution, and pH of the combined water and acid antimicrobial solution; a flow meter for monitoring and one variable pump for supplying an acid antimicrobial solution to the treatment system; mixing said acid antimicrobial solution into the water to create an aqueous antimicrobial solution; adjust in real-time the amount of acid antimicrobial solution supplied to the system by said variable pump compared to the amount of water supplied to the system to maintain a desired strength of said aqueous antimicrobial solution. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is obvious over IUS 2014/0305881 A1 to Alarid, et al. (hereinafter 'Alarid'). Alarid discloses treatment of food work pieces with apparatus (para [0076]), comprising: a processor (para [0047]); a pump and a flow meter for supplying and monitoring water to the treatment system (para [0005], [0033], [0036], metering valve, flow meter... monitor... wherein metering devices are considered pumps.); water, and acid antimicrobial solution, and pH of the combined water and acid antimicrobial solution (para [0043], [0050], mixture of water and chlorine species as a microbiological control and disinfection... pH monitoring and control.); a flow meter for monitoring and one variable pump for supplying an acid antimicrobial solution to the treatment system (para [0033], [0038], [0053], auto metering control valve and magnetic flow meter... monitoring chlorine dioxide concentration and pH.); mixing said acid antimicrobial solution into the water to create an aqueous antimicrobial solution (para [0042], [0043], mixed aqueous chlorine dioxide and chlorine oxidant feed stream.);
adjust in real-time the amount of acid antimicrobial solution supplied to the system by said variable pump compared to the amount of water supplied to the system to maintain a desired strength of said aqueous antimicrobial solution (para [0039], [0042], [0043], adjust/increase feed rates for disinfection... mixed aqueous chlorine dioxide and chlorine oxidant feed stream fed automatically for real time strength of strong disinfectant.); but does not specifically disclose that said processor includes a memory.
To a person of ordinary skill in the art, it would have been obvious through routine experimentation to select amongst known processors for use in calculating and comparing values in order to optimize the adjustment of the strength of disinfecting agent.

As the technical features were known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups. Groups I and II therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.