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TITLE OF THE INVENTION

APPARATUS FOR REMOVING IMPURITIES IN AIR ✓

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus for removing impurities in air, and more particularly, to an apparatus for removing impurities having a water quality control function for controlling the pH value of an absorbing solution used for absorbing and removing soluble gases contained in the air through gas-liquid contact.

2. Description of the Related Art

For introducing outside air, through an outside air supplier, into a clean room for which a certain level of cleanliness is required, an apparatus for removing soluble gases contained in the outside air through gas-liquid contact has been well known, as is disclosed, e.g., in Japanese Patent Application Laid-open No. Hei 9-253442.

The apparatus for removing soluble gases in air disclosed in the aforementioned application removes soluble gases in air by causing an absorbing solution to absorb the soluble gases therein while allowing the absorbing solution such as water or pure water to efficiently come in gas-liquid contact with the air containing the soluble gas component

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therein.

The absorbing solution is sprayed from spray nozzles within a passage (e.g., a wind tunnel) through which the air to be processed passes, and dissolves and absorbs the soluble gas component through gas-liquid contact. Then, the absorbing solution having the soluble gas component dissolved therein is recovered, and the recovered absorbing solution is circulated within a circulation system so as to be introduced into the passage through which the air to be processed flows.

When the absorbing solution continuously removes the soluble gases while circulating within the circulation system, the quality of the absorbing solution in the circulation system deteriorates because the concentration of the absorbed gases increases. In order to prevent such a deterioration in the quality of the absorbing solution, part of the absorbing solution in the absorbing solution circulation system is drained, and the corresponding amount of replenishing water is supplied.

However, when the soluble gases in the air to be processed are more acidic than alkaline, the absorbing solution in the absorbing solution circulation system tends to be more acidic even if the concentration of all the absorbed gases is not increased, and as a result, the rate at which the absorbing solution removes the acidic gases is

decreased.

To overcome this problem, an impurity mixing method has heretofore been used to control the pH value of the absorbing solution in the absorbing solution circulation system. In the impurity mixing method, an acidic or alkaline pH regulating solution, or a pH buffer solution in which an acid substance and an alkaline substance are blended in predetermined amounts is introduced into an absorbing solution so as to adjust the pH value of the absorbing solution within a predetermined range. The chemical solutions used in this case include sulfuric acid, hydrochloric acid, nitric acid and oxalic acid as acid chemicals, and amine-containing chemicals as alkaline solutions.

However, in the impurity mixing method, most of the vapor components of the used chemical solutions are contained in the air to be processed as substances to be removed. As a result, when the absorbing solution is vaporizing or when the absorbing solution is carried over to the downstream side of the processing apparatus, etc., part of these chemicals may vaporize in the already processed supply air to thereby increase the concentration of the removed gas component. Hence, the vaporized chemicals would be potential contaminants.

SUMMARY OF THE INVENTION

The present invention has been made to overcome the aforementioned problems, and therefore has an object of the present invention to provide an apparatus for removing impurities in air, which controls within a predetermined input range the pH value of an absorbing solution for absorbing soluble gases in air to be processed without increasing the concentration of the removed gas component in the already processed supply air, and which hence controls the quality of the absorbing solution.

The present invention provides an apparatus for removing impurities in air which has the following construction in order to overcome the aforementioned technical problems. That is, one aspect of the present invention provides an apparatus for removing impurities in air in which soluble gas impurities in air to be processed are absorbed and removed by a gas-liquid contact method, comprising: an absorbing solution circulation system for supplying an absorbing solution into a passage through which the air to be processed flows, dissolving soluble gases in the air to be processed into the absorbing solution while causing the absorbing solution and the air to be processed to come in gas-liquid contact with each other, and recovering the absorbing solution having the soluble gases dissolved

therein and supplying the recovered absorbing solution back into the passage; and a selective ion controller for controlling the pH value of the absorbing solution within a predetermined range.

In the apparatus for removing impurities in air of the present invention, the selective ion controller detects the pH value of the absorbing solution in the absorbing solution circulation system, and controls the pH value of the absorbing solution within a predetermined range by selectively adjusting either positive or negative ions of the absorbing solution based on the detected pH value.

In the apparatus for removing impurities in air of the present invention, the selective ion controller controls the pH value of the absorbing solution within a predetermined range by selectively removing either positive or negative ions of the absorbing solution in the absorbing solution circulation system.

The apparatus for removing impurities in air of the present invention may further comprise an absorbing solution replenishment system for supplying the absorbing solution circulation system with a fresh absorbing solution, and an absorbing solution drainage system for draining part of the absorbing solution from the absorbing solution circulation system.

In this case, the selective ion controller selectively removes either positive or negative ions from the fresh absorbing solution supplied through the absorbing solution replenishment system, and replenishes the absorbing solution circulation system with the replenishing absorbing solution from which the ions have been removed, so that the pH value of the absorbing solution in the absorbing solution circulation system is controlled within a predetermined range.

In the thus constructed apparatus for removing impurities in air of the present invention, the selective ion controller may be based on an electrolytic separation/removal method or may use an ion exchange resin. Pure water or water may be used as the absorbing solution. It is preferable to set the pH value of the absorbing solution in the absorbing solution circulation system within the range from 5.0 to 8.0.

According to the apparatus for removing impurities in air of the present invention, the soluble gas component in the air is absorbed and removed by the absorbing solution while the absorbing solution in the absorbing solution circulation system are in gas-liquid contact with the air to be processed within the air passage. As a result, the pH value of the absorbing solution in the absorbing solution circulation system comes to lose its balance. For example,

when acidic gas component in the air to be processed increases, the absorbing solution in the absorbing solution circulation system tends to be more acidic.

To overcome this problem, in the apparatus for removing impurities in air of the present invention, the pH value of the absorbing solution in the absorbing solution circulation system is measured successively by, e.g., a pH sensor or the like, and when the pH value gets out of a predetermined range, the selective ion controller controls the concentration of ions in the absorbing solution so that the pH value of the absorbing solution is brought back within the set range.

The following two techniques are generally available for controlling the concentration of the ions in the absorbing solution circulating within the absorbing solution circulation system. (1) In one technique, the selective ion controller directly removes excessive positive or negative ions in the absorbing solution circulating within the absorbing solution circulation system to thereby control the pH value within the set range. (2) In the other technique, a replenishing absorbing solution is supplied to the absorbing solution circulating within the absorbing solution circulation system, and during the replenishment, the selective ion controller removes positive or negative

ions in the replenishing absorbing solution to thereby control the pH value of the absorbing solution in the absorbing solution circulation system within the set range.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a diagram schematically illustrating the construction of an apparatus for removing impurities in air in accordance with a first embodiment of the present invention;

FIG. 2 is a diagram schematically illustrating the construction of an apparatus for removing impurities in air in accordance with a second embodiment of the present invention;

FIG. 3 is a partial diagram illustrating the construction of a modified example in which the location of a selective ion controller in each of the apparatuses for removing impurities in air shown in FIGS. 1 and 2 is modified;

FIG. 4 is a diagram schematically illustrating the construction of an apparatus for removing impurities in air in accordance with a third embodiment of the present invention;

FIG. 5 is a diagram schematically illustrating the construction of an apparatus for removing impurities in air

in accordance with a fourth embodiment of the present invention; and

FIG. 6 is a partial diagram illustrating the construction of a modified example in which the location of a selective ion controller in the apparatus for removing impurities in air shown in FIG. 5 is modified.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An apparatus for removing impurities in air of the present invention will now be described in more detail with reference to embodiments shown in the drawings.

(First Embodiment)

FIG. 1 is a diagram schematically illustrating the construction of an apparatus for removing impurities in air (hereinafter referred to simply as "removing apparatus") 10 in accordance with a first embodiment of the present invention. The removing apparatus 10 in one aspect is applied to an air washer for supplying air to a clean room by removing soluble gases from the air outside the clean room.

In this embodiment, the gas-liquid contact between an absorbing solution and the air to be processed will be described by exemplifying a case where the contact takes place within a wind channel, i.e., a chamber 11 inserted along a duct. The outside air, which is the air to be processed, circulates from the left to the right through the

chamber 11 as indicated by the arrow 12 in FIG. 1. A absorbing solution spraying section of a pure water circulation system (absorbing solution circulation system) 13 is provided in the chamber 11. The system 13 circulates and supplies pure water, which is the absorbing solution.

The pure water circulation system 13 comprises a line 13a and a circulation pump 15. One end of the line 13a communicates with a pit 11a provided within the chamber 11, and on the other end are formed many spray nozzles 14. The pump 15 pumps up the pure water that is stored in the pit 11a through the line 13a, and sprays the pumped-up pure water into the chamber 11 from the nozzles 14, which serves as the absorbing solution spraying section within the chamber 11.

Lines 16a and 17a are connected to the pit 11a. The line 16a constitutes a pure water replenishment system (absorbing solution replenishment system) 16 for supplying highly pure, fresh pure water. The line 17a constitutes a pure water drainage system (absorbing solution drainage system) 17 for draining the pure water from the pit 11a. A drain pump 18 is provided on the line 17a of the pure water drainage system 17. The pump 18 constantly drains a predetermined amount of pure water, and in correspondence thereto, fresh pure water is continuously supplied from the pure water replenishment system 16.

The replenishment of the pure water from the pure water replenishment system 16 is controlled by an overflow 16a valve (not shown) which is provided on an end of the line and which utilizes a float 16b. As a result of the control, the pure water can be supplied in the same amount as it is drained. Further, within the chamber 11, an eliminator 19 for recovering splashing mists is provided downstream of the pit 11a.

The line 13a constituting the pure water circulation system 13 has a pH sensor 20 for successively measuring the pH value of the pure water circulating via the line 13a. A selective ion controller 21 is located on the line 13a downstream of the pH sensor 20.

The selective ion controller 21 uses, e.g., an electrolytic separation/removal method or an ion exchange resin, and removes positive or negative ions in the pure water. The controller 21 is a known device. The operation of such controller 21 is controlled by a control signal from a pH control unit 22. The unit 22 generates the control signal in response to an output signal from the pH sensor 20.

Next, the operation of the removing apparatus 10 will be described. Within the chamber 11, the pure water is successively sprayed from the spray nozzles 14, and the sprayed pure water comes in gas-liquid contact with the

outside air circulating in the chamber 11, thereby causing soluble gases contained in the outside air to be dissolved into the pure water. At the same time, the sprayed pure water reaches the eliminator 19 that is located downstream, thereby wetting the eliminating surface of the eliminator 19 and again absorbing and removing the soluble gases thereon.

The pure water that has absorbed the soluble gases in this way is stored in the pit 11a, and the stored pure water is sprayed again from the spray nozzles 14 through the pure water circulation system 13. That is, the pure water is successively circulated within the pure water circulation system 13 by a circulation pump 15. While the pure water is being successively circulated, the concentration of the soluble gases in the pure water that is circulating in the pure water circulation system 13 increases as time goes on, and at the same time, the quality of the pure water tends to be more acidic or more alkaline, losing a balance.

When the concentration of the soluble gases in the pure water becomes higher than a predetermined value, the gas absorbing efficiency of the pure water is reduced. Therefore, the pure water stored in the pit 11a is drained in a predetermined amount by the drain pump 18 through the pure water drainage system 17. In correspondence thereto, the pit 11a is replenished with the same amount of fresh pure water

from the pure water replenishment system 16. As a result, the concentration of the soluble gases in the pure water is controlled so as to be substantially within predetermined values.

On the other hand, when the pH value of the pure water exhibits an imbalance, the pH control unit 22 receiving the output signal from the pH sensor 20 detects this imbalance, and sends the selective ion controller 21 an instruction signal for correcting the imbalance, i.e., a control signal. Based on the control signal, the selective ion controller 21 selectively removes either positive ions or negative ions in the pure water.

That is, let us set the desirable pH value of the pure water within the range from 5.5 to 7.5. When the acid gas component in the air to be processed increases and the pure water in the pure water circulation system 13 becomes more acidic to thereby decrease the pH value to 5.5 or lower, the pH value control unit 22 receiving the output signal from the pH sensor 20 controls the operation of the selective ion controller 21 so that only negative ions in the pure water are selectively removed so as to increase the pH value of the pure water. When the selective ion controller 21 has corrected the pH value in the pure water circulation system 13 within the set range, the pH control unit 22 instructs the

selective ion controller 21 to stop its operation.

As a result, the pH value of the pure water in the pure water circulation system 13 is controlled within the set range at all times. Consequently, the rate at which the pure water removes acid gases or alkaline gases can be stabilized, and in addition, there will be no such inconvenience as an increased concentration of the removed gas component caused by the vaporization of chemical solutions, which is encountered when, e.g., the impurity mixing method, which is the conventional method, is used.

(Second Embodiment)

In the aforementioned removing apparatus 10 in accordance with the first embodiment, the pure water control is effected by the float 16b provided at the end of the line 16a so that the predetermined amount of pure water is stored in the pit 11a within the chamber 11 at all times, even while the pit 11a is replenished with the pure water from the pure water replenishment system 16.

However, there provides a removing apparatus 10 in accordance with a second embodiment shown in FIG. 2, in which a predetermined amount of pure water can be stored in the pit 11a similarly by positioning a drain port end 17b of the line 17a constituting the pure water drainage system 17 at a pure water storage level within the chamber 11. Therefore, there

is no need to provide the float 16b at the end of the line 16a in the pure water replenishment system 16.

Further, in the removing apparatus 10 in accordance with the first embodiment shown in FIG. 1, the pure water is forcibly drained by the drain pump 18 arranged in the pure water drainage system 17. However, in place of the pump 18, a supply pump 23 is provided on the line 16a in the pure water replenishment system 16 as shown in FIG. 2, so that the pit 11a can be replenished with the pure water at all times by an amount of the pure water corresponding to that of pure water drained from the pure water drainage system 17.

Further, in each of the removing apparatuses 10, in accordance with the first and second embodiments shown in FIGS. 1 and 2, the selective ion controller 21 is provided directly on the line 13a constituting the pure water circulation system 13 so as to selectively remove ions in the total amount of pure water circulating through the line 13a. However, as shown in FIG. 3, a bypass pipe 13b may be provided downstream of the pH sensor 20, and the selective ion controller 21 may be provided on the bypass pipe 13b. As a result of this construction, ions can be selectively removed from part of the pure water circulating within the pure water circulation system 13.

(Third Embodiment)

Next, an apparatus for removing impurities in air, in accordance with a third embodiment of the present invention, will be described. FIG. 4 is a diagram schematically illustrating the construction of an apparatus for removing impurities in air 30, in accordance with the third embodiment. The apparatus for removing impurities in air 30 is distinguished from the apparatus for removing impurities in air 10, in accordance with the first embodiment shown in FIG. 1, in the following points.

In the apparatus for removing impurities in air 30 in accordance with the third embodiment, the selective ion controller 21 is not provided on the line 13a in the pure water circulation system 13. Instead, the controller 21 is attached to a pH value recovery pipe 31 that is provided so as to bypass the pure water from the pit 11a and return the pure water directly to the pit 11a. Other than this, the apparatus 30 is substantially the same as the apparatus for removing impurities in air 10 in accordance with the first embodiment shown in FIG. 1, and hence its description will be omitted with its components denoted by the same reference numerals in FIG. 4.

According to the thus constructed apparatus for removing impurities in air 30, when the pH value of the pure water circulating within the pure water circulation system 13

gets out of the set range, the pH control unit 22 detects it based on the output signal from the pH sensor 20, and the unit 22 then sends an operation control signal to the selective ion controller 21, so that positive ions or negative ions in the pure water stored in the pit 11a are selectively removed to thereby bring the pH value back within the set range.

(Fourth Embodiment)

Next, an apparatus for removing impurities in air, in accordance with a fourth embodiment of the present invention, will be described. FIG. 5 is a diagram schematically illustrating an apparatus for removing impurities in air 40, in accordance with the fourth embodiment. The apparatus 40 is distinguished from the apparatus for removing impurities in air 10 in accordance with the first embodiment as shown in FIG. 1 in the following point.

In the apparatus for removing impurities in air 40 in accordance with the fourth embodiment, the selective ion controller 21 is not located on the line 13a in the absorbing water circulation system 13, but is attached to the line 16a in the water replenishment system 16. Other than this, the apparatus 40 is substantially the same as the apparatus for removing impurities in air 10 in accordance with the first

embodiment shown in FIG. 1, and hence its description will be omitted with its components denoted by the same reference numerals in FIG. 5.

According to the thus constructed apparatus for removing impurities in air 40, when the pH value of the water circulating within the absorbing water circulation system 13 gets out of the set range, the pH control unit 22 detects it based on the output signal from the pH sensor 20, and the unit 20 then sends an operation control signal to the selective ion controller 21, so that positive ions or negative ions in the water flowing through the water replenishment system 16 are selectively removed.

For example, let us set the desirable pH value of water within the range from 6.0 to 7.5. When the acid gas component in the air to be processed increases and the water in the water circulation system 13 becomes more acidic to thereby decrease the pH value to 6.0 or lower, the pH value control unit 22 that has received the output signal from the pH sensor 20 instructs and controls the selective ion controller 21 so that only negative ions in the replenishing water are selectively removed.

As a result, the replenishing water with its negative ions removed is supplied through the pit 11a to the acidic water that is circulating within the water circulation

system 13, and hence the pH value of the water is brought back within the set range. When the pH value has been recovered within the set range, the pH control unit 22 instructs the selective ion controller 21 to stop its operation. As a result, the pH value of the water in the water circulation system 13 is controlled within the set range at all times, and hence the rate at which the water removes acidic or alkaline gases can be stabilized.

Note that the selective ion controller 21 is also provided directly on the line 16a constituting the water replenishment system 16 in the apparatus for removing impurities in air 40 in accordance with the fourth embodiment, and hence ions are selectively removed in the total amount of water flowing through the line 16a. However, as shown in FIG. 6, a bypass pipe 16c is provided along the line 16a, and the selective ion controller 21 is provided on the bypass pipe 16c, so that ions can be selectively removed from only part of the water flowing through the water replenishment system 16.

Note also that the apparatuses for removing impurities in air in accordance with the first to third embodiments, use pure water as the absorbing solution for absorbing the soluble gas component contained in the air to be processed. However, the absorbing solution is not limited

to pure water in the present invention, and hence water or various types of well-known absorbing solutions can be used.

Further, the apparatus for removing impurities in air, in accordance with the fourth embodiment, uses water as the absorbing solution for absorbing the soluble gas component contained in the air to be processed. However, the absorbing solution is not limited to water in the present invention, either, and hence various types of well-known absorbing solutions can be used.

Still further, in the apparatuses for removing impurities in air of the present invention, it is preferable to set the pH value of the absorbing solution in the absorbing solution circulation system within the range from 5.0 to 8.0. Further, in the apparatuses for removing impurities in air of the present invention, it is preferable to use a selective ion controller based on the electrolytic separation/removal method and a selective ion remover using the ion exchange resin and to switch them with a switching valve, while providing them in parallel with each other on the line.

As described in the foregoing, according to the apparatus for removing impurities in air of the present invention, the pH value of an absorbing solution in the absorbing solution circulation system is detected, and

positive or negative ions in the absorbing solution are selectively adjusted based on the detected pH value to thereby control the pH value within a predetermined range. As a result, the rate at which the absorbing water removes acidic or alkaline gases can be stabilized without causing such inconvenience as the increased concentration of impurities in the absorbing solution or the increased concentration of removed gas component in the air due to the vaporization of chemical solutions which have been observed in the conventional impurity mixing method.

What is claimed is:

1. An apparatus for removing impurities in air in which soluble gas impurities in air to be processed are absorbed and removed by a gas-liquid contact method, comprising:

an absorbing solution circulation system for supplying an absorbing solution into a passage through which the air to be processed flows, dissolving soluble gases in the air to be processed into said absorbing solution while causing said absorbing solution and the air to be processed to come in gas-liquid contact with each other, and recovering said absorbing solution having the soluble gases dissolved therein and supplying the recovered absorbing solution back into the passage; and

a selective ion controller for controlling the pH value of said absorbing solution within a predetermined range.

2. An apparatus for removing impurities in air according to claim 1, wherein said selective ion controller detects the pH value of said absorbing solution in said absorbing solution circulation system, and controls the pH value of said absorbing solution within a predetermined range by selectively adjusting either positive or negative ions in said absorbing solution based on the detected pH value.

3. An apparatus for removing impurities in air according to claim 1, wherein said selective ion controller detects the pH value of said absorbing solution in said



absorbing solution circulation system, and controls the pH value of said absorbing solution within a predetermined range by selectively removing either positive or negative ions of said absorbing solution in the absorbing solution circulation system.

4. An apparatus for removing impurities in air in which soluble gas impurities in air to be processed are absorbed and removed by a gas-liquid contact method, comprising:

an absorbing solution circulation system for supplying an absorbing solution into a passage through which the air to be processed flows, dissolving soluble gases in the air to be processed into said absorbing solution while causing said absorbing solution and the air to be processed to come in gas-liquid contact with each other, and recovering said absorbing solution having the soluble gases dissolved therein and supplying the recovered absorbing solution back into the passage,

an absorbing solution replenishment system for supplying said absorbing solution circulation system with a fresh absorbing solution, an absorbing solution drainage system for draining part of said absorbing solution from said absorbing solution circulation system, and

a selective ion controller being provided to said absorbing solution replenishment system, and controls the PH value of said fresh absorbing solution within a predetermined range supplied through said absorbing solution replenishment



system.

5. An apparatus for removing impurities in air according to claim 4, wherein said selective ion controller detects the pH value of said absorbing solution in said absorbing solution circulation system, and controls the pH value of said absorbing solution in said absorbing solution circulation system within a predetermined range by selectively adjusting either positive or negative ions in said absorbing solution of said absorbing solution replenishment based on the detected pH value of said absorbing solution circulation system.

6. An apparatus for removing impurities in air according to claim 4, wherein said selective ion controller detects the pH value of said absorbing solution in said absorbing solution circulation system, and controls the pH value of said absorbing solution in said absorbing solution circulation system within a predetermined range by selectively removing either positive or negative ions of said absorbing solution in said absorbing solution replenishment system based on the detected pH value of said absorbing solution circulation system..

7. An apparatus for removing impurities in air according to claim 3 or 6, wherein said selective ion controller is based on an electrolytic separation/removal method.

8. An apparatus for removing impurities in air according to claim 3 or 6, wherein said selective ion



controller uses an ion exchange resin.

9. An apparatus for removing impurities in air according to claim 2, 3, 5 or 6, wherein said absorbing solution is pure water.

10. An apparatus for removing impurities in air according to claim 9, wherein the pH value of said absorbing solution in said absorbing solution circulation system ranges from 5.0 to 8.0.

11. An apparatus for removing impurities in air according to claim 2, 3, 5 or 6, wherein said absorbing solution is water.

12. An apparatus for removing impurities in air according to claim 11, wherein the pH value of said absorbing solution in said absorbing solution circulation system ranges from 5.0 to 8.0.

