July 6, 1954 R. L. KUEHNER 2,683,074

PROCESS FOR DEODORIZING AND STERILIZING AIR

Filed Nov. 28, 1949

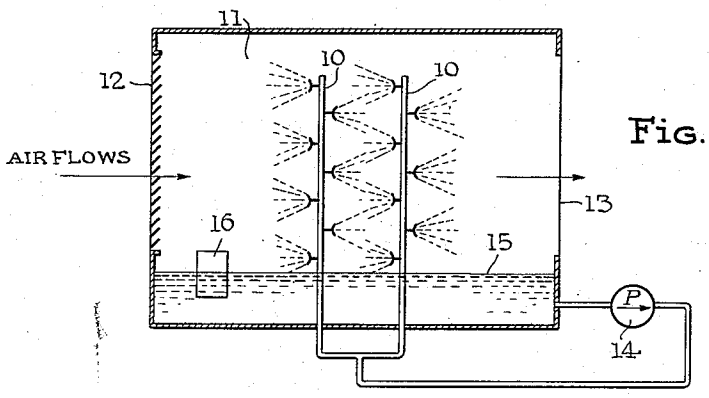


Fig. 1

Fig. 2

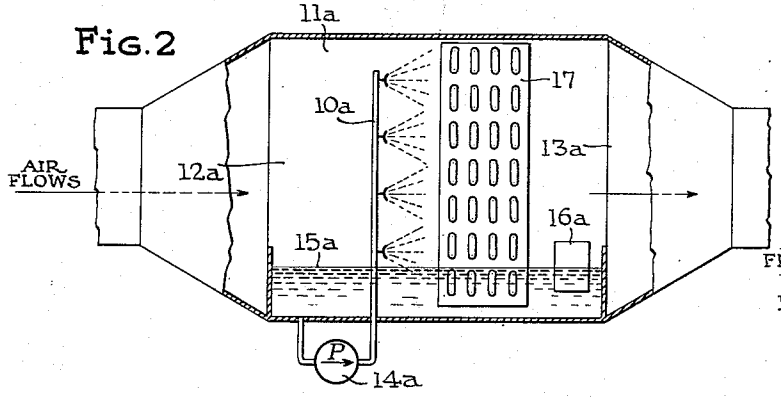


Fig. 5

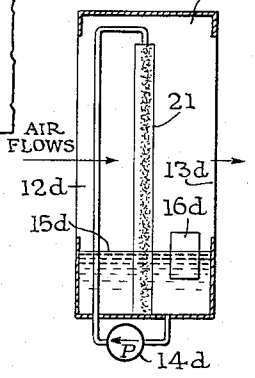


Fig. 3

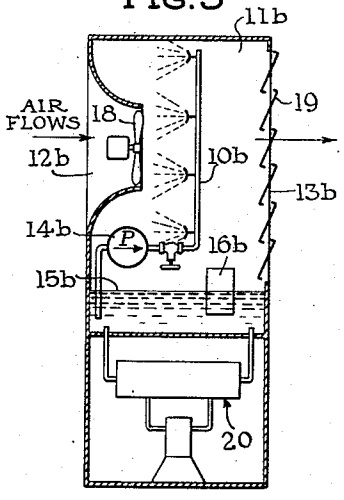
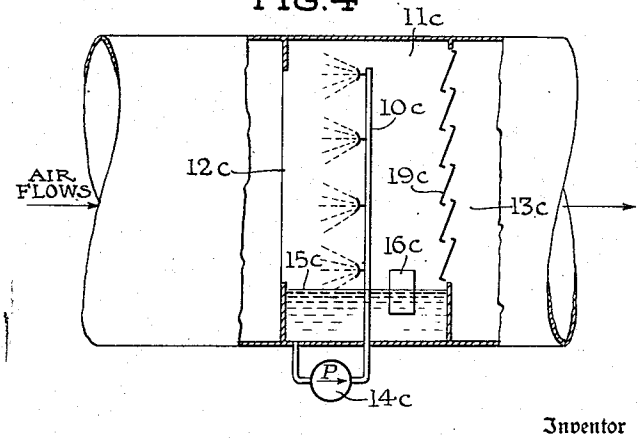


Fig. 4



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Patented July 6, 1954

2,683,074

UNITED STATES PATENT OFFICE

2,683,074

PROCESS FOR DEODORIZING AND STERILIZING AIR

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Application November 28, 1949, Serial No. 129,725

2 Claims. (Cl. 21—53)

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This invention relates to improvements in air conditioning systems and is more particularly directed to a method and means for purifying and improving the quality of air in occupied enclosures so as to render the air free of odors, sterile and comfortable at all times. It is a specific object of the invention to reduce odors, bacteria (both harmful and non-harmful) and molds in circulated air.

The invention makes it possible to furnish in an inexpensive manner an abundant supply of sterile air which, in addition to being cooled and dehumidified, approaches in characteristics normal fresh outside air.

In air conditioning systems employing recirculation of air, there takes place a rapid build-up of bacteria and odors and the concentration of these components eventually exceeds the human toleration level. It has been attempted, in the past, to remedy this situation by diluting the inside air with a continuous supply of fresh outside air; it will be apparent, however, that this solution entails the provision of excessively large equipment for dehumidifying and tempering the continuously added fresh air, thereby increasing not only the initial cost of the installation, but also the operating and maintenance costs.

In contrast with prior attempts, this invention permits reduction of odors, bacteria and mold concentrations in conditioned air to satisfactory levels without the addition of excessively large quantities of fresh outside air for dilution purposes, or the incorporation of expensive equipment. My invention resides in treating the air to be purified with a chemical mixture which has the property of removing odors, bacteria and molds therefrom. In particular, I have discovered that excellent results are obtained by treating odor and bacteria-laden air with an aqueous alkaline solution of potassium permanganate. That is, I have found that an alkaline solution of potassium permanganate is more effective for removing odors, bacterias and molds and improving the condition of the treated air than is potassium permanganate alone. Fundamentally, the action of my treating solution is one of oxidation, which is performed by the permanganate, but I have discovered that the presence of the alkalizing agent is essential for the practical and efficient use of the permanganate for the following reasons:

1. The disinfectant qualities of potassium permanganate are increased in an alkaline solution;

2. The deodorant qualities of potassium permanganate are increased in an alkaline solution;

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3. Potassium permanganate is less corrosive in an alkaline solution and, therefore, less harmful to the equipment, and

4. Potassium permanganate has no tendency to spontaneous, useless breakdown in an alkaline solution.

The use of an alkaline treating solution is additionally highly advantageous from the standpoint of preventing contact of equipment with an acid menstruum which corrodes the equipment wherever there is a water-metal contact. Further, an acid menstruum renders $KMnO_4$ corrosive and also causes the spontaneous breakdown of the $KMnO_4$. It is apparent, therefore, that the use of $KMnO_4$ in an alkaline solution is not only directly beneficial in that the disinfectant and deodorant qualities of the permanganate are enhanced, but is further desirable from the standpoint of the preservation of equipment and the stability of the treating solution.

In actual practice, using high concentrations of chemicals in the treating solution, comparative tests with (*a*) a neutral permanganate, and (*b*) alkaline permanganates—e. g. a sodium hydroxide-potassium permanganate mixture and sodium bicarbonate-potassium permanganate mixture—have shown that air treated with the alkaline permanganate has at least 45% less odor than air treated with the neutral permanganate, all other conditions being the same. In fact, in the case of the bicarbonate, the air contained about 58% less odor. When the chemicals are used in low concentrations, the superiority of the alkaline solutions persists. Moreover, the use of the alkaline solution of the present invention gives uniform, high and rapid bacteria kill and mold destruction, as contrasted with the sporadic effect of the neutral permanganate solution.

As evidence of the improved results which are obtained by the use of my alkaline solution of potassium permanganate for deodorizing, I am setting forth below the data obtained with comparative tests. In these tests, cigarettes were burned directly into three tubes of the different test solutions, respectively containing (1) neutral potassium permanganate, (2) potassium permanganate alkalized with NaOH, and (3) potassium permanganate alkalized with $NaHCO_3$. The residual odor left in the air after passing through the tests solutions under identical conditions, was measured by determining the amount of a standard $KMnO_4$ test solution reduced by the residual odor. My experiments over a considerable number of years have indicated that this procedure constitutes an accurate and precise

method of measuring odors, the concentration of odor being directly reflected by the amount of $KMnO_4$ reduced. The numerical data yielded by the tests are set out below:

Residual odor left in air after passing through high concentration neutral and alkaline $KMnO_4$ under identical conditions

Treating Solution	Solution reduced by residual odor in air stream after deodorization
Neutral $KMnO_4$	6.28 ml. N/10 $KMnO_4$.
$KMnO_4$ and NaOH	3.48 ml. N/10 $KMnO_4$.
$KMnO_4$ and $NaHCO_3$	2.67 ml. N/10 $KMnO_4$.

Comparison of the figures readily shows that the residual odor left in the air after passing through a solution alkalized with NaOH is much less, by

$$\frac{6.28-3.48}{6.28}\times 100$$

or 45%, than that left after passage through a neutral $KMnO_4$ solution, since the residual odor reduced 3.48 ml. of the odor measuring test solution, as against 6.28 when the air was preliminarily treated with neutral permanganate solution. Still better results were obtained when air was preliminarily treated with a permanganate solution alkalized with $NaHCO_3$, since the residual odor was only capable of reducing 2.67 ml. of the odor measuring test solution and, hence the residual odor left in the air in this instance is

$$\frac{6.28-2.67}{6.28}\times 100$$

or about 58% less than in the case of treatment with a neutral permanganate solution.

By the use of my invention, satisfactory results have been obtained under actual working conditions of various air conditioning systems, including dry coil systems under both summer and winter conditions and washer type systems. However, it is to be emphasized that the use of my invention is not restricted to any particular type of air conditioning or treating system. The more intimate the contact of the air with the treating solution, the more effective is the treatment according to my invention. In practice, excellent results are obtained by passing the air stream to be treated through a curtain of finely divided particles of the treating solution. The chemical is effective when distributed in humidifying sprays, whether in the washer type or the dry type. In the case of dry systems, I have found that particularly good results are obtained by pouring the solution of the chemical on top of the cooling coils with the air flowing upwardly through the solution between the finned coils. However, it is to be understood that the practice of my invention is not limited to the spraying of the solution into the air stream or to the passing of the solution over finned coils, between which the air to be treated passes. Any apparatus which gives an intimate contact between the air and the treating solution is satisfactory for the purpose of my invention. Thus, the solution can be poured over metal or glass wool or fibers through which is passed the air to be treated.

To render the aqueous potassium permanganate solution alkaline, there can be used any suitable alkalizing compound having a cation which does not react with the permanganate radical, since such reaction would precipitate the anion MnO_4 from the solution and thereby render it ineffective. I have successfully used sodium bicarbonate and alternatively, sodium hydroxide to form the alkaline solution mixture. While sodium hydroxide is a good alkalizing agent and increases the activity of the potassium permanganate as an air deodorant and disinfectant, the use of the bicarbonate is preferable. Among other advantages, the bicarbonate exerts a buffering action to maintain the alkalinity of the solution mixture, notwithstanding the presence of substantial amount of CO_2 in the air being treated. This is so, because of the excessive presence of the bicarbonate ion which prevents the dissociation of the dissolved carbonic acid and, accordingly, inhibits solution of undue amounts of CO_2 from the air into the treating liquid. The treating solution is therefore maintained continuously basic. In other words, the bicarbonate radical does not react with the carbonic acid but only suppresses its concentration by reducing the solubility of CO_2 in the water. I have determined that only 0.05 gram of sodium bicarbonate per liter of liquid will retain that liquid decidedly alkaline, no matter how much air is passed through it.

This buffering action of the sodium bicarbonate constitutes an important feature of my invention because its mere presence in even minute quantities prevents the water menstruum from becoming acidic. The use of sodium bicarbonate in the treating solution does not involve a chemical reaction resulting in inert residues or a pile of end products which must be cleaned out periodically. The addition of sodium bicarbonate maintains a given alkalinity in the solution over an indefinite period of time. It is apparent that the advantageous buffering action of sodium bicarbonate may be utilized in all instances where air or other gases are treated with an aqueous medium and it is desired to inhibit the acidification of the aqueous medium by the absorption of CO_2 from the gas being treated.

As explained above, the effectiveness of the potassium permanganate solution is substantially improved by utilizing a solution mixture which is at all times maintained on the alkaline side. In preparing suitable treating solutions, the ratio by weight of sodium bicarbonate to potassium permanganate is about 1 to 2.5 and the weight of permanganate per liter of water ranges from 0.13 gm. to .25 gm. In the case of sodium hydroxide-potassium permanganate solution, the ratio of the weight of sodium hydroxide to the weight of potassium permanganate used is 1 to 2.5, and the amount by weight of potassium permanganate per liter of water ranges from 0.13 gm. to 0.25 gm. While I have mentioned sodium hydroxide and sodium bicarbonate, it is to be understood that any of the other alkali metal and alkali earth metal hydroxides and bicarbonates may be used, as long as they, or any other alkalizing agent, do not contain a cation which precipitates the permanganate radical as above mentioned. The important feature of the invention is that the solution mixture is always on the alkaline side.

In order to economize in the use of chemicals, it is my aim to use the most dilute treating solution possible, especially in air washer systems where there is a continuous or intermittent overflow of the washer solution down a drain due to the condensation of moisture from the air. The lower limit for the concentration of potassium permanganate per liter of water was determined by the ability of the solution to kill certain common airborne pathogenic bacteria in a specified period of time. In a normal washer the water

makes one recirculation in 40 seconds. Accordingly, it is theoretically possible, although improbable, that a pathogenic organism can enter the washer system from the air and be discharged back into the air within 40 seconds. Therefore, I have determined by experiments that lower limit of concentration of alkalized potassium permanganate which destroys these pathogens within 40 seconds. This lower limit is 0.13 gram of potassium permanganate per liter of water, as specified above. The reaction of the oxidant with the odor will take place in any concentration but will, of course, follow the law of mass action in that the speed will vary with the concentration. Therefore, the lower limit was established on the basis of the germicidal properties of the resultant solution and, for proper effectiveness, the concentration must not drop below this specified minimum. But I can go to any concentration above this minimum, which fits the particular application. The range of 0.13 to 0.25 gram of permanganate per liter of water is a practical range, based on my experiments. These established that one charging of the washing water to the maximum concentration—i. e. 0.25 gram of potassium permanganate per liter of water—would last for one week in a practical washer system without dropping below the minimum concentration of 0.13 gram. Concentrations higher than 0.25 may, of course, be used but, where there is an overflow of the solution down a drain, it is economically unsound to use higher concentrations because of the useless waste of chemicals. It should be pointed out that the value given above for the minimum concentration of potassium permanganate in the treating solution is based upon an assumed time of contact between the air and the treating solution. However, where a longer time of contact than that assumed is used, lower concentrations of chemicals can be employed.

In the accompanying drawings, I have illustrated several systems in which the invention finds useful application but, as heretofore indicated, the invention is not limited to any specific system. In the drawings,

Figure 1 is a diagrammatic view of a typical washer using my invention;

Figure 2 is a diagrammatic view of a typical embodiment of my invention in a dry coil unit;

Figure 3 is a diagrammatic view of my invention applied in a typical air washer system which may or may not be associated with a refrigerating unit;

Figure 4 is a diagrammatic view of a simple form of unitary apparatus for carrying out my invention, and

Figure 5 is a diagrammatic view of still another form of apparatus for carrying out my invention.

Referring to Figure 1, the unit has the usual spray devices **10** for spraying the treating liquid, and which are interposed in the path of the air stream which enters the compartment **11** at one end **12** thereof and leaves at the other end **13**. The liquid circulating means is indicated at **14**, the liquid accumulating in the bottom of the compartment to the level indicated at **15**.

The chemicals may be added to the treating water in the compartment, or the water may be preliminarily prepared by adding the chemicals thereto and introducing the same to the circulating system. The chemicals may be introduced to the treating water individually or as mixtures in the form of dry powders, concentrated aqueous solutions or as pills or tablets, whichever is considered most convenient. The numeral **16** indicates a suitable receptacle for replenishing the chemicals in the solution to maintain the desired concentration thereof, and this receptacle may be manually operated to dispense chemicals into the circulating solution mixture, or suitable means may be provided for automatically carrying out the dispensing, either continuously or intermittently in the case of the powder or concentrated solution, and intermittently in the case of tablets or pills. Such automatic dispensing means are well known in the art and may be controlled by any one of the factors characteristic of the circulating solution—e. g. departure from its normal concentration or color intensity.

In the practical operation of my invention, the rate of addition of the treating chemicals can be readily varied in order to meet the odor load. As will be appreciated, this rate of addition of the chemicals must also take into consideration the type of air treating system used that is, whether it is of the overflow or non-overflow type. Thus, in the case of air washer systems where there is a continuous or intermittent overflow of the washer solution down a drain due to the condensation of moisture from the air, both the alkalizer e. g. the bicarbonate and the potassium permanganate may be made up continuously. In other types of installations replenishment of chemicals need only take place at rare intervals. In one type of washer system used experimentally by me, the addition of chemicals was only made once a week.

In Figure 2—in which the same reference numerals are used for the same parts except that they also have a differentiating letter—the unit differs from that of Figure 1 only by the presence of a bank of cooling coils **17** interposed in the compartment **11***a* and through which the air stream passes. In Figure 3 the unit is substantially the same as shown in Figure 1, except that a fan **18** is used at the inlet end **12***b* of the compartment **11***b*, and eliminator baffles **19** are provided at the exit end **13***b*. A refrigerating unit **20** may be employed with this unit, in which event, the solution will be circulated therethrough. However, the use of this refrigerating unit is not necessary and it can be omitted. The apparatus shown in Figure 3 may be used either as a deodorizer and sterilizer, or for cooling the air as well.

Figure 4 illustrates a unitary apparatus—generally represented by the numeral **11***c*—for carrying out my invention and consisting of no more than the chemical reservoir **16***c*, pump **14***c*, sprays **10***c* and eliminator baffles **19***c* combined as a unit adapted for incorporation in any duct through which air is passing. As will be observed, no blower is used in this instance and the combination is of such a nature that it can be easily inserted in the air duct of any air conditioning or ventilating system, whether new or old, or can be attached to the side, or within, any air conditioning unit.

It is preferable to pass the air stream through a spray of the treating solution mixture because in this manner intimate contact of the air with the finely divided liquid particles is obtained. My invention is however not restricted in its application to arrangements in which the chemical solution used for treating the air is sprayed into the air or sprayed onto coils, as in the embodiments illustrated in Figures 1 to 4. Any other means for contacting the liquid with the air or

subjecting the latter to treatment with the improved solution mixture may be employed. I can use an arrangement, as illustrated diagrammatically in Figure 5 in which the chemical solution is poured on the top of any fibrous or granular material 21 through which it trickles down and this material, wetted with treating solution, presents a large contacting surface for the air stream passing therethrough. Any material can be used which is non-reactive with the disinfectant-deodorant chemical treating solution. I have successfully used glass wool, brass wool and copper mesh fillers.

It will be seen, therefore, that my invention consists in treating the air to be purified with an aqueous solution of a mixture of inexpensive, non-toxic, non-corrosive readily available compounds. I have discovered that when these chemicals are present in the air treating solution in concentrations above a certain minimum, as above described, they effectively remove odors of various types, including body odors and cooking odors, bacteria and molds from an air stream rendering the latter odorless and sterile, so that the treated air actually contains less odor and bacteria than normal, fresh outside air. The use of the invention put no toxic or irritant vapors into the air and leaves no large quantities of inert residue to be cleaned out of the system, and actually keeps the system free of dirt, grease and other organic accumulations. These results can be obtained in practical air conditioning systems without change in the operating procedure. Additionally, in the case of washer type air conditioning systems, the presence of my air-sanitizing compound in the wash water eliminates the necessity for the regular cleaning of the system to prevent contamination of the air by the accumulation of microbes and odors in the dirty wash water. This constitutes a considerable savings in expense and time since the average washer system must be cleaned out once a week. In contrast with this, a system containing my disinfectant-deodorant mixture may require cleaning but once a season or once a year.

As will be apparent from the foregoing description, my invention has universal adaptability and fits all types of air conditioning and ventilating systems, humidification and dehumidification systems or can be embodied in a separate unitary system. My invention is adapted for use at all seasons of the year and the chemical treating solution can be used for deodorizing and sterilizing air in spaces even in the absence of means for dehumidifying and tempering the air.

What is claimed is:

1. In the process of deodorizing and sterilizing air circulated in occupied enclosures by bringing the air in intimate contact with an aqueous solution of potassium permanganate in which the permanganate is present in the amount of at least 0.13 gramme per litre of water, the improvement of advantageously inhibiting the acidification of the aqueous solution by absorption of CO_2 from the air which consists in: adding a buffer compound to the aqueous solution, said compound being selected from the group consisting of alkali metal and alkali earth metal bicarbonates, and being present in an amount effective to maintain the solution alkaline.

2. Process according to claim 1, in which the buffering agent is $NaHCO_3$ and is present in the amount of at least 0.05 gramme per litre of water.

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