United States Patent

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[54] **FOG ABATEMENT**
8 Claims, 3 Drawing Figs.

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[51] Int. Cl. B03c 3/00
[50] Field of Search .... 317/262 R; 98/1, DIG. 1; 55/107, 122, 123, 5, 10, 18

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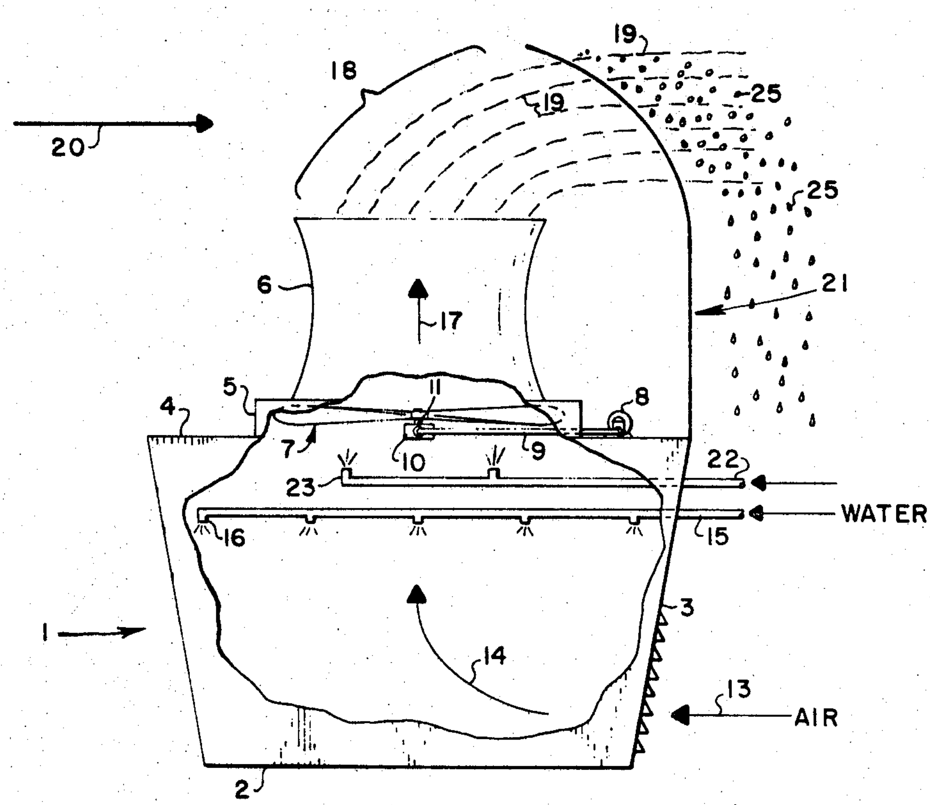
ABSTRACT: A method and apparatus for increasing visibility through fog by employing an electrical field to force liquid particles in the fog together to form large drops of sufficient mass to precipitate from the fog under the force of gravity.



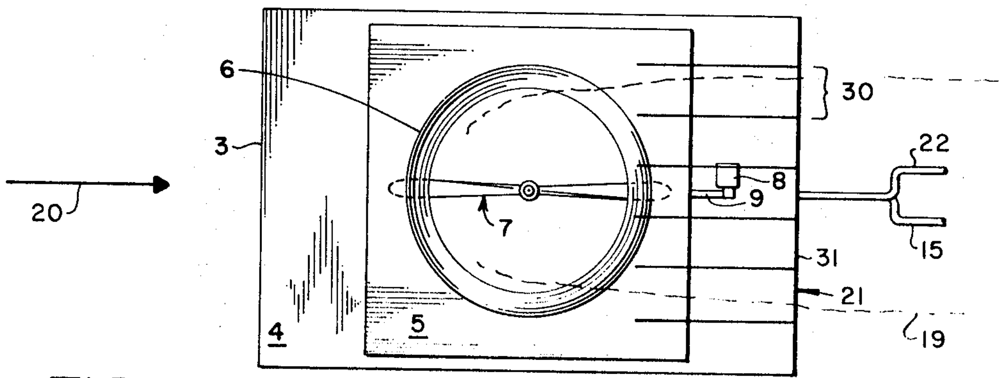


FIG. 2

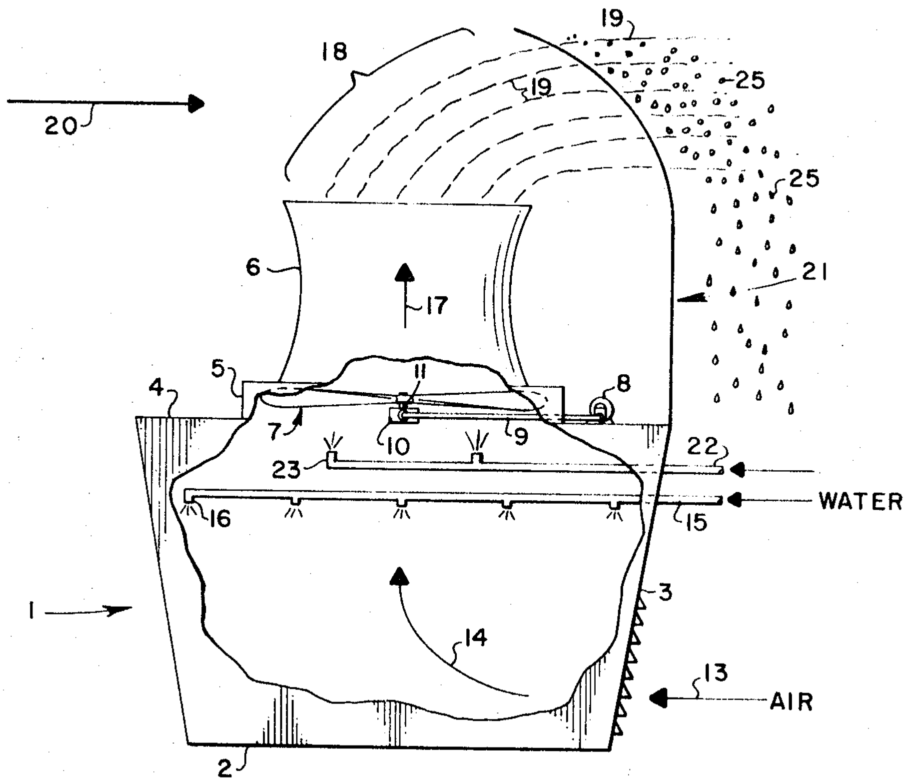


FIG. 1

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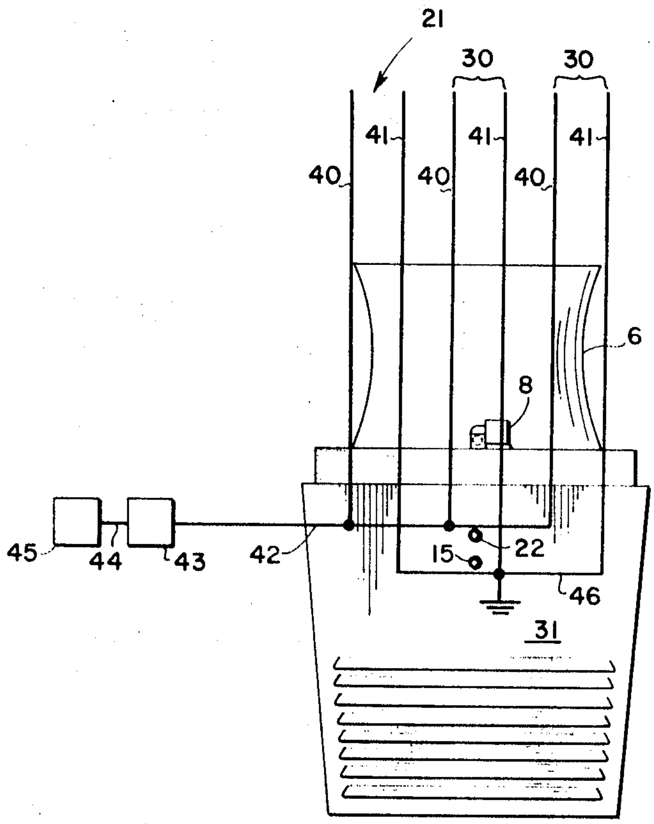

FIG. 3

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FOG ABATEMENT

BACKGROUND OF THE INVENTION

Water cooling towers and other apparatus normally associated with industrial plants emit an air stream in large volume, i.e. hundreds of thousands of cubic feet per minute. The air stream is at a temperature substantially above normal ambient conditions, particularly in the winter time. The air stream is also saturated with water vapor and contains some entrained water particles.

Thus, when the heated, water-laden air from its source mixes with and is diluted by ambient air just outside the source, water condenses from the air and forms a dense fog or plume.

Although these fogs are nothing more than a mixture of water and air and, in fact, are cleaner than ambient air because they have been washed with water, they appear to the unknowing to be smoke which is contaminating the air.

Further, these fogs can create a visibility problem if carried by the wind over a highway, air field, industrial plant, or any other entity where visibility of a number of people at the same time is necessary for operations to continue normally.

Therefore, a clear and present problem exists with apparatus which under certain conditions emits a dense fog and it is highly desirable to have a method for reducing the fog density and thereby increasing the visibility through that fog. The method should be economical, uncomplicated in form, and itself nonpolluting.

Heretofore, burners have been employed to heat the water saturated air as it passes from its source. Electrostatic precipitation of the water from the air is not considered practical because the volume and speed of the water-laden air leaving the source is too great for a precipitator of anywhere near conventional size to remove the water therefrom. In other words, it would take too large a precipitator apparatus to allow all the water carried by the air to coagulate on the collector electrode of the precipitator to be drained down that electrode into a sump. This is the normal operation for a precipitator, i.e. the particles in the gas stream are pushed by the corona (electrical field) away from the discharge electrode toward the collecting electrode to be caught by the collecting electrode and removed therefrom. Thus, electrostatic precipitators in their normal operation are considered not suitable for solving this problem.

SUMMARY OF THE INVENTION

According to this invention an electrical field is established and at least part of the fog passed through this field, the strength of the electrical field being carefully controlled so that liquid particles in the fog are forced together to form larger liquid drops which are of sufficient mass to precipitate from the fog due to the force of gravity.

In this manner no attempt is made to precipitate the liquid from the fog on an electrode, but rather the liquid particles in the fog are forced closer together to cause them to coalesce into larger drops which rain out of the fog. This reduces the density of the fog and increases the visibility therethrough.

It should be understood that this invention does not primarily, by way of its electrical field, cause the removal of water or other liquid from a fog by way of the liquid collecting on the collector electrode as is normal for electrostatic precipitators. The electrical field of this invention coalesces liquid particles in the fog so that they rain out of the fog after the fog has left the vicinity of the electrical field and the electrodes.

Accordingly, in addition to a method for coalescing liquid particles in a fog to subsequently rain out of the fog and clarify same, this invention relates to apparatus for reducing fog density from an outlet thereof utilizing at least one pair of electrode means arranged in a manner relative to the fog outlet so that at least part of the fog passes between the electrode means.

This invention is useful in reducing the density and increasing the visibility through the fog formed from one or more liquids so long as at least one of the liquids is sufficiently electrically active to be movable under the force of an electrical field. Thus, this invention is applicable to fogs containing liquid particles other than or in addition to water. However, this invention is particularly applicable to the abatement of water fog, particularly from apparatus sources such as water cooling towers.

Accordingly, an object of this invention is to provide a new and improved method for fog abatement. Another object is to provide a new and improved method for coalescing liquid particles in a fog. Another object is a new and improved method for utilizing electrical fields to cause the formation of liquid drops in a fog of sufficient mass to rain out of the fog under the force of gravity. Another object is to provide a new and improved apparatus for treating fog to reduce the density thereof and to increase the visibility therethrough. It is another object to provide a new and improved apparatus for coalescing liquid particles in a fog. Another object is a new and improved method and apparatus for reducing water fog emitted by water cooling towers.

Other aspects, objects, and advantages of this invention will be apparent to those skilled in the art from this disclosure and the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. 1 through 3 show elevational and plane views of a conventional water cooling tower employing one embodiment of this invention.

More specifically, FIG. 1 shows an elevational view of one cell of a conventional counter flow, induced draft cooling tower **1** which has a bottom section **2**, main walls **3**, and a top section **4**.

Top section **4** includes a fan space **5** surmounted by a fan stack **6**. Fan space **5** contains a conventional fan **7** powered by motor means **8**. Motor **8** is operatively connected by drive shaft **9** to a conventional gear box **10**. Fan shaft **11** is operatively connected to gear box **10**.

The lower portion of main walls **3** contains air intake louvers (not shown) through which air is drawn, as shown by arrows **13** and **14**, from outside the cooling tower into a lower portion thereof and upwardly toward fan **7**.

Water enters in the upper portion of the cooling tower by way of pipe **15** and is sprayed downwardly toward the incoming air by way of a plurality of spray nozzles **16**. In this manner the water is cooled by contact with the air. The air becomes saturated with water vapor and picks up some entrained water particles. The water is collected at bottom **2** and removed by conventional means not shown.

The water saturated air continues upwardly through fan stack **6** as shown by arrow **17** and outwardly where it is mixed with and diluted by outside air which is at an ambient temperature.

Normally, the water to be cooled in pipe **15** is at a temperature of at least about 100° F. and the water saturated air leaving fan stack **6** is at a temperature of at least about 90° F. In situations where the ambient temperature is less than 90° F. and/or the ambient air has a high humidity, i.e. from 60 to 100 percent humidity, the water dissolved in the fan stack air will condense in area **18** and form a dense fog represented by undulating lines **19**.

FIG. 1 shows a wind blowing in the direction of arrow **20** so that fog **19** is blown toward a plurality of pairs of electrodes **21** mounted on sidewall **3**. Electrodes **21** extend upwardly, toward, and over fan stack **6** but are spaced therefrom a sufficient distance so that fog can first form in area **18**.

As an additional embodiment to the basic invention hereof, another pipe **22** extends inwardly into tower **1** and carries spray nozzles **23** which are adapted to disperse a desired additive into the air which will ultimately be emitted from fan stack **6**. As will be discussed in more detail hereinafter, pipe

22 can be utilized to introduce an additive into the air which will improve its electrical conductivity and thereby help in the removal of liquid particles from fog 19.

In operation, the fog formed in area 18 passes in part between two electrodes of a given pair of electrodes 30 (FIG. 2). One electrode in the pair is at a higher electrical potential than the other so that a corona or electrical field is established. The electrode at the higher potential is the discharge electrode and the electrode at the lower potential is the collecting electrode in the normal sense, but not in the sense of this invention in that in this invention a collecting electrode is not used for collecting liquid from the fog passing thereby.

As fog 19 passes between the two electrodes, the liquid particles in the fog are acted upon by the electrical field and forced closer to one another so that a substantial number of these particles coalesce with one another to form larger liquid drops. These liquid drops are then of sufficient mass that the force of gravity acting thereon overcomes the carrying force of the mass velocity of the fog and the larger drops rain out after leaving electrodes 21 as shown by reference numeral 25.

Thus, the collecting electrodes in each pair 30 do not take liquid from the fog but merely cause coalescence of liquid particles in the fog to cause liquid drop rain out after leaving electrodes 21. By inducing coalescence of liquid particles and by allowing the subsequent raining out of these particles, the fog density is substantially decreased and, therefore, the visibility through the fog is substantially increased.

FIG. 2 shows a plane view of the tower of FIG. 1 and shows a plurality of pairs of electrodes 30 arranged along side 31 of main wall 3. Each pair 30 is connected in a manner discussed hereinafter in detail in in FIG. 3 so that one is at a higher potential than the other. By the ionizing effect of the electrical field on the liquid particles in the fog, the particles are agitated and collide with one another and in so doing coalesce. Put another way, momentum transfer of ions streaming from the discharge or higher potential electrode to the collecting electrode produces a lateral motion of the liquid particles between the electrode by the electric wind passing from the discharge electrode to the other electrode. However, the coalesced liquid particles do not collect to a substantial degree on the collecting electrode as in the normal electrostatic precipitator operation but rather leave the electrical field in the coalesced condition. Thus, the electrical field strength is controlled so that the liquid particles in the fog are forced together to form larger liquid drops but without causing substantial amounts of liquid condensation on the collecting electrode. This is quite different from normal electrostatic precipitator operation.

Depending upon the ambient atmosphere and its physical conditions, the composition of the fog, the configuration and relationship of the electrodes to one another, and the like, an electric field strength suitable for this invention can vary widely but generally is that which will cause the liquid particles in the fog to be forced together in the manner described above. Generally, the electrical potential difference between two electrodes of each pair 30 should be at least about 5000 volts per inch of spacing between the two electrodes. The electrical potential difference can be established using either a direct current or alternating current, as desired.

The electrical conductivity of the fog can further be improved so that the liquid particles in the fog will be more subject to being moved by the action of the electrical field by introducing a suitable additive material by way of pipe 22 and nozzles 23 (FIG. 1). A suitable additive or additives will vary widely depending upon the materials being treated and the like but will generally be a material which itself is subject to ionization by the electric field. For example, ammonia or ammonium salts such as ammonium halides (particularly ammonium chloride), ammonium sulfate, ammonium nitrate, and the like, can be employed. Of course, mixtures of two or more of these materials can be used. These additives are normally employed in amounts effective to increase the amount of coalescence of liquid particles in the fog passing between the two electrodes. Generally, finite amounts up to about 100 parts per million, preferably up to about 10 parts per million, can be employed.

FIG. 3 shows the cooling tower of FIGS. 1 and 2 viewed toward side 31 of FIG. 2 so that the pairs of electrodes 30 can be seen. Each pair of electrodes is composed of a discharge electrode 40 and a collecting electrode 41. Discharge electrodes 40 are electrically connected by means of wire 42 to rectifier 43 which in turn is electrically connected by wire 44 to a voltage source 45. Collecting electrodes 41 are operatively connected by means of wire 46 to ground. Thus, an electric field is set up between electrodes 40 and 41 in each pair of electrodes 30 so that substantially all fog passing from fan stack 6 passes through an electric field.

The electrodes can be mounted on main walls 3 of the cooling tower or on the periphery of fan stack 6 or any combination thereof. The electrodes can completely surround the fan stack or extend around any desired portion thereof. For example, the electrodes can be disposed on one side as shown in FIG. 3 or two or three or all sides, as desired.

The electrodes themselves can be of any conventional configuration. For example, the discharge electrode will normally be a wire or plate and the collecting electrodes can be a rod curtain, a corrugated plate, dual perforated plates, plates with fins to increase surface area, and the like. Various electrode combinations and configurations as well as the conventional methods by which they can be connected to one another and operated to establish an electrical field therebetween are fully and completely disclosed in an engineering report prepared for the American Petroleum Institute entitled "Removal of Particulate Matter from Gaseous Waste—Electrostatic Precipitators," 1961, American Petroleum Institute, Division of Refining, 1271 Avenue of the Americas, New York, New York. The subject matter of this report is incorporated herein by reference.

EXAMPLE

A water cooling tower substantially as shown in the drawings is used to cool heated water from a catalytic cracking unit. The cooling tower is designed to remove 300 million B.t.u. per hour from 24,000 gallons per minute of water introduced by pipe 15. The water enters the cooling tower at about 100° F., falls downwardly in the cooling tower, contacts upcoming ambient air, saturates the upcoming air with water, and heats the upcoming air to about 90° F.

When the ambient conditions around fan stack 6 are such that the ambient air is at a temperature lower than 90° F. and the ambient humidity is about 100 percent, the heated, water saturated air emitted from the top of fan stack 6, after mixing with ambient air, forms a dense fog because of the precipitation of water from the heated, saturated air as it is cooled by the ambient air.

Pairs of electrodes substantially as that shown in the drawings are employed, each pair having an electrical potential difference of about 5000 volts per inch of spacing between electrodes. That portion of fog passing between two electrodes of each pair of electrodes has a substantial portion of its fog forming particles forced into contact with one another to coalesce same into raindrop size liquid drops. The drops rain out of the fog primarily after the fog has left the vicinity of the electrodes and the influence of electric field between those electrodes. The degree of fog density decrease and visibility increase is varied widely by varying the strength of the electric field between the electrodes and the electrical conductivity of the fog itself.

Reasonable variations and modifications are possible within the scope of this disclosure without departing from the spirit and scope of this invention.

I claim:

1. In a method for reducing fog density from a source thereof to increase visibility therethrough, the improvement comprising passing at least part of said fog between at least

one pair of electrodes, establishing an electrical potential difference between the two electrodes of each pair of electrodes so that an electrical field is established between the two electrodes by the electrode which is at the higher potential, controlling the electrical field strength so that liquid particles in said fog are forced together to form larger liquid drops without collecting on an electrode, said larger liquid drops being of sufficient mass to precipitate from said fog due to the force of gravity after leaving said electrical field.

2. In a method for reducing fog density from a source thereof to increase visibility therethrough, the improvement comprising dispersing in said fog an additive which improves the electrical conductivity of said fog, passing at least part of said fog between at least one pair of electrodes, establishing an electrical potential difference between the two electrodes of each pair of electrodes so that an electrical field is established between the two electrodes by the electrode which is at the higher potential, controlling the electrical field strength so that liquid particles in said fog are forced together to form larger liquid drops without collecting on an electrode, said larger liquid drops being of sufficient mass to precipitate from said fog due to the force of gravity after leaving the electrical field.

3. A method according to claim **2** wherein said fog is a water fog and the fog source is a water cooling tower.

4. A method according to claim **2** wherein said electrical potential difference is at least about 5000 volts per inch of spacing between the two electrodes of each pair of electrodes.

5. A method according to claim **2** wherein said electrical potential difference is established using direct current.

6. A method according to claim **2** wherein said material is at least one of ammonia and ammonium salts.

7. A method according to claim **2** wherein said ammonia is present in finite amounts up to about 10 parts of ammonia per million parts of water in said fog.

8. A method according to claim **2** wherein said electrical potential difference is established using alternating current.