Title: AMMONIA REMOVAL FROM AN AQUEOUS SOLUTION AND METHOD FOR THE PRODUCTION OF A FERTILIZER MATERIAL

Abstract: The invention provides method for the removal of ammonia from air and converting the ammonia in a fertilizer material, comprising (a) contacting at least part of the air with an aqueous liquid, wherein the aqueous liquid is a solvent for ammonia, to provide an ammonia containing aqueous liquid, and (b) contacting the ammonia containing aqueous liquid with a polysaccharide containing waste product. The invention further provides a fertilizer production arrangement comprising (1) an ammonia condenser arrangement, configured to remove ammonia from a gas and to provide an ammonia containing aqueous liquid, and (2) a contacting unit, configured to contact the ammonia containing aqueous liquid with a polysaccharide containing waste product.
Ammonia removal from an aqueous solution
and method for the production of a fertilizer material

Field of the invention

The invention relates to a method for the removal of ammonia from air. The invention further relates to a method for the production of a fertilizer material. Further, the invention relates to a fertilizer production arrangement as well as to an accommodation arrangement.

Background of the invention

The formation of ammonia is a well-known problem in agriculture. Several solutions are provided.

WO2006058537, for instance, describes a liquid manure facility for a pig stable of the type having a slotted floor disposed directly over a liquid manure channel or similar pit for collecting the liquid manure. The collected liquid manure is discharged intermittently to an interim tank according to the "pull the chain" principle, as the emptying e.g. occurs by removing a removable bottom plug in the pit, where after the liquid manure by its own action flows through a pipe system having an inclination to the interim tank. The invention of WO2006058537 consists in that a funnel-shaped scoop is disposed under the slotted floor, and which at the bottom is provided with a closable gate valve or similar shut-off device. Further by the funnel-shaped scoop discharging into a relatively small closed collecting tank disposed under the scoop, and that in connection with the interim tank a vacuum system is arranged, operating periodically emptying the collecting tank by vacuum action. I.e. the emptying of the collecting tank occurs by suction or pumping of the contents through a closed pipe system between the tank and the interim tank. The liquid manure tank according to the invention is distinguished by handling the liquid manure in an almost hermetically closed tank and pipe system which is gas- and odour-tight, so that the emission of odours and ammonia in the stable are minimised. The vacuum emptying system eliminates the need for subsequent flushing, further contributing to improved animal welfare and improved working environment in the stable. The emission of ammonia and bad-smelling stable air to the surroundings via the ventilation system of the stable is reduced with up to 80%.
US2002020677 describes an integrated farm animal waste treatment system for treating solid and liquid farm animal wastes while recovering waste heat energy generated during the treatment process. The preferred embodiment includes a portable chemical treatment process that can be moved from one waste processing site to another in order to treat a variety of different types of animal waste in varying amounts on a batch basis. The preferred embodiment provides for the destruction of hazardous solids, liquids and gases. In addition, the process includes means to isolate and recover valuable by-products of farm animal waste, such as nitrogen and ammonia, for use in manufacturing commercial-grade fertilizer. The preferred embodiment also includes means for capturing waste heat for use either internally in the waste treatment process itself or, alternatively as a source of heat for the farm creating the animal wastes. The same basic process, but with additional, more permanent features, can be installed and operated on either a batch or continuous basis as a permanent installation, depending on the need within a particular farming community.

Other art is directed to the prevention or reduction of the formation of ammonia. For instance, US 2007218168 describes an animal feed that employs a substantially indigestible cation exchanger capable of binding ammonium cations and an acidogenic substance to acidify an animal's manure and thereby create ammonium cations that can be bound by the cation exchanger. The animal feed reduces ammonia emissions from manure produced by animals fed the animal feed compared to the emissions obtained from manure when an acidogenic substance is fed alone and compared to the emissions obtained from manure when a cation exchange capacity material is fed alone. According to another aspect of the present invention, a method of lowering ammonia emissions from manure is provided. The present invention also provides a method for reducing soluble phosphorus levels in manure and a method for reducing total phosphorus levels in manure. In a further aspect of the present invention, a method is provided that yields manure that may be used alone or in concert with other materials to act as a fertilizer having advantageous ecological properties. Another aspect of the present invention provides a method for reducing insect populations associated with manure.
Summary of the invention

A disadvantage of prior art may be that complex methods are needed and/or specific food is needed to prevent, reduce or solve the problem of formation ammonia or handling of ammonia. Further, the ammonia formed may not be removed in an economic and sustainable way.

There is however a need for reducing the exhaust of ammonia (i.e. NH₃) or other undesired gasses, for instance since those gasses may be detrimental to health and/or may contribute to the greenhouse effect and/or are considered unpleasant. Examples of gasses of which an exhaust reduction may be desired are for instance ammonia (NH₃), acetone (C₃H₆O), dinitrogen oxide (N₂O), hydrogen sulphide (H₂S), ethylene (C₂H₄), fluor (F₂) or chlorine (Cl₂).

Hence, it is an aspect of the invention to provide an alternative method for the problem of formed ammonia, especially formed in an animal accommodation (formed by the animal(s) hosted therein), which preferably further at least partly obviates one or more of above-described drawbacks. It is further an aspect of the invention to reuse the ammonia formed in a sustainable and/or useful way. It is also an aspect of the invention to provide an apparatus (herein further called arrangement), that can be used to remove the ammonia and/or reuse in a sustainable and/or useful way.

In a first aspect, the invention provides a method for the removal of ammonia (NH₃) or another undesired specie (see for instance above) from a gas, especially air, and converting the ammonia (or other undesired specie) in a fertilizer material, comprising:

a. contacting at least part of the gas, such as air, with a liquid, especially an aqueous liquid, wherein the liquid, especially the aqueous liquid is a solvent for ammonia or the other undesired specie, to provide an ammonia and/or other specie containing aqueous liquid; and

b. contacting the ammonia and/or other containing aqueous liquid with a polysaccharide containing product, especially a polysaccharide containing waste product (“waste product”).

The method of the invention thus relates in general to the production of fertilizer material based on polysaccharide containing waste product and an ammonia (or other undesired specie) containing aqueous liquid. Hence, in another (general) aspect, the invention provides a method for the production of a fertilizer material comprising
mixing an ammonia containing liquid with a polysaccharide containing waste product. The ammonia containing liquid is an ammonia containing aqueous liquid, especially ammonia containing water.

Herein, the invention is in general further described with reference to an aqueous liquid, with reference to ammonia, and with reference to a polysaccharide containing waste product. However, the principle of the invention may also be applied in a method for the removal of an undesired specie from a gas and converting the undesired specie into fertilizer material, especially with the aid of an aqueous liquid which is a solvent for the undesired specie.

The polysaccharide containing waste product may be a cellulose containing waste product, a hemicellulose containing waste product, a cellulose containing waste product, etc. Especially, the polysaccharide containing waste product comprises a cellulose containing waste product.

By contacting the ammonia containing aqueous liquid with the polysaccharide containing product, ammonia is bound to the product. Hence, ammonia is captured, and the product may be reused, especially as fertilizer. Therefore, the invention especially provides a method for the removal of ammonia from air and converting the ammonia in a fertilizer material, comprising:

a. contacting at least part of the air with an aqueous liquid, wherein the aqueous liquid is a solvent for ammonia, to provide an ammonia containing aqueous liquid; and

b. contacting the ammonia containing aqueous liquid with a polysaccharide containing waste product.

In this way, waste (ammonia) and waste may in an economical and sustainable way be combined to a useful product. Here below, those methods are further elucidated. For the sake of understanding, it is referred to “the method”.

The air may especially the air in an animal accommodation, such as an accommodation is selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm. Such air may comprise a relatively high CO₂ content, which may be beneficial for the scavenging of ammonia (see also below).

The air may in an embodiment be sucked or blown out of an accommodation to another place, or especially arrangement, where the air is treated. However, in another embodiment, the air may be treated within the accommodation, or part of the treatment,
such as the production of the ammonia containing aqueous liquid may be performed within the accommodation wherein the air is present and part of the treatment, especially the contacting part may be performed outside that accommodation.

Anyhow, at least part of the air (from such accommodation wherein air comprising ammonia is present) is contacted with an aqueous liquid, wherein the aqueous liquid is a solvent for ammonia, to provide an ammonia containing aqueous liquid. The aqueous liquid may especially comprise water. Ammonia may solve in water relatively easily. However, the aqueous liquid may in an embodiment also comprise a mixture of water and another liquid. When the air also contains carbon dioxide (CO₂), ammonia may dissolve faster and higher dissolved ammonia contents may be reached under the formation of ammonium carbonate ((NH₄)₂CO₃).

In an embodiment, the method comprises mixing at least part of the air and the aqueous liquid to provide the ammonia containing aqueous liquid. For instance, the ammonia containing air may be scrubbed (in a scrubber) with the aqueous liquid. The ammonia containing aqueous liquid may be produced by the scrubber.

In a further embodiment, the method comprises atomizing the aqueous liquid to provide an aqueous liquid haze, contacting at least part of the air with the aqueous liquid haze, and condensing at least part thereof to provide the ammonia containing aqueous liquid. The haze droplets may scavenge ammonia. Those haze droplets may be condensed, to provide the ammonia containing aqueous liquid, which may then be used further to produce the fertilizer material as described herein.

In a specific embodiment, the invention provides a method, comprising:

a. applying an electric field between a first electrode arranged to generate a corona discharge and a second electrode, comprising an haze-permeable electrically conductive sieve of a plurality of conductive strands;

b. atomizing the aqueous liquid to provide a aqueous liquid haze between the first and the second electrode;

c. arranging a substrate behind, relative to the first electrode, the second electrode;

d. collecting aqueous liquid formed at the substrate as ammonia containing aqueous liquid; and

e. contacting the ammonia containing liquid with a polysaccharide containing waste product.
This method is further elucidated below. An advantage of this method is also that particulate matter (PM) or fine particles are collected (at the substrate). Hence, this method may allow a scavenging of ammonia and particulate matter, and a conversion of this material, together with the polysaccharide containing waste product into a useful fertilizer material. In an embodiment, the substrate may be cooled. In general, a substrate, especially a cooled substrate, may be used to facilitate condensation of the aqueous liquid (from the haze).

Hence, here contacting may include contacting the ammonia containing gas with a haze of aqueous liquid, or scrubbing the ammonia containing gas with an aqueous liquid, or bubbling the ammonia containing gas in the aqueous liquid, etc.

The polysaccharide containing waste product may in an embodiment comprises a product selected from the group consisting of fruit, vegetable, and vegetation. The polysaccharide containing waste product may also comprise a product selected from the group consisting of organic litter (such as one or more of household litter, a residue from for instance fruit, vegetable and vegetation, (used) ground coffee beans) and manure (such as animal manure or human manure, but especially animal manure, like manure comprising one or more of chicken manure, pig manure and bovid manure (especially cattle manure (such as from cows))). The polysaccharide containing waste product comprises a food residue (such as one or more bread or a meal residue).

Specific embodiments of the polysaccharide containing waste product are selected of the group comprising biomass waste (containing polysaccharide), such as coffee residue (see also above), cacao residue, grass, wood pulp, paper pulp, corn stover (especially leaves of corn), woodchips, or cattle manure. Paper or cardboard may also be applied. Algae may be applied as well.

As will be clear to the person skilled in the art, the term “waste product” may in an embodiment also refer to a plurality of waste products.

Preferably, the waste product comprises at least 0.5 wt% (dry weight), preferably at least 1 wt.% (dry weight), more preferably at least 2 wt.% (dry weight), even more preferably at least 5 wt.% (dry weight), such as in the range of 0.5-100 wt.%, such as 1-80 wt.% (dry weight) polysaccharide. Such as 1-50 wt.% (dry weight).

Optionally, the waste product may be pre-treated, such as one or more of grinding, particulating, and drying.
Contacting the ammonia containing aqueous liquid and the polysaccharide containing waste product may be performed in several ways.

For instance, the two products may be mixed, and after mixing, the thus obtained product can be used as fertilizer material. Optionally, part of the liquid may be removed, to obtain a drier fertilizer material, especially in when the mixture has a high liquid content. Hence, in an embodiment, the phrase “contacting the ammonia containing aqueous liquid with a polysaccharide containing waste product”, and similar phrases, may refer to a mixing of the two materials. In a further embodiment, the method may further involve separating the with ammonia enriched polysaccharide containing waste product as fertilizer material from the ammonia depleted liquid. Preferably, however, the complete mixture is applied, in order to prevent residual waste.

However, after a first separation, the thus obtained liquid may in an embodiment be contacted again with the waste product (i.e. now the ammonia enriched polysaccharide containing waste product). This may be repeated several times. In this way, the waste product may be more and more enriched with ammonia, and the ammonia containing aqueous liquid may be more and more depleted with ammonia. It may even be possible to substantially remove all ammonia. Hence, in an embodiment, the method of the invention may further involve separating the with ammonia enriched polysaccharide containing waste product as fertilizer material from the ammonia depleted liquid, wherein the ammonia depleted liquid after separation is contacted (i.e. a second contact of the ammonia containing aqueous liquid with the waste product) with the ammonia enriched polysaccharide containing waste product, and optionally repeating this one or more times.

Before, during and/or after contacting the ammonia containing liquid and polysaccharide containing waste product, also other materials may be added, to provide a fertilizer material with further additive. For instance, one or more of P, Ca, Mg, Zn and K fertilizer may be added, but also trace elements as Fe, Cu, Mo, B, Mn, I, etc. may be added. Hence, the method may further comprise adding one or more of P-containing material and K-containing material, and optionally also adding one of more of Ca-containing material, Mg-containing material, Zn-containing material, a Fe-containing material, a Cu-containing material, a Mo-containing material, a B-containing material, a Mn-containing material, and I-containing material. Hence, the
method may especially comprise adding one or more of P-containing material and K-containing material, and optionally also adding one or more of Ca-containing material, Mg-containing material, Fe-containing material and I-containing material. The addition could be done with animal faeces, such as pig or chicken poop. In most of the faeces, these trace element are present, and will be in itself a fertiliser.

The method of the invention may be applied for any kind of ammonia polluted air. This may be air from an industrial process wherein ammonia is produced (as pollutant, such as in the production of urea, etc.). However, this may especially be the air from an animal accommodation. Hence, the invention especially provides a method for the removal of ammonia from air in an accommodation, wherein the accommodation is selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm.

In a further aspect, the invention also provides a fertilizer production arrangement comprising (1) an ammonia condenser arrangement, configured to remove ammonia from a gas and to provide an ammonia containing aqueous liquid, and (2) a contacting unit, configured to contact the ammonia containing aqueous liquid with a polysaccharide containing waste product.

As indicated above, though the ammonia condenser arrangement and the contacting unit being in liquid contact which each other (since the ammonia containing aqueous liquid is to be introduced into the contacting unit), they may be arranged at some distance from each other and/or in different rooms or compartments.

In an embodiment, the ammonia condenser arrangement may comprise a liquid atomizer, configured to atomize the aqueous liquid to provide an aqueous liquid haze. The haze droplets scavenge the ammonia. After condensing the haze droplets (enriched with ammonia), the ammonia containing aqueous liquid is obtained.

In another embodiment, the ammonia condenser arrangement comprises a gas-liquid mixer, configured to mix the aqueous liquid and the air containing ammonia. For instance, this may be a scrubber.

The ammonia containing aqueous liquid preferably comprises NH₃ (or in general more precisely NH₄⁺) in an amount of 10⁻⁷-10⁻¹ mol/l, especially 10⁻⁶-10⁻² mol/l. Typically the pH is around 10, such as in the range of 9-11.

In a specific embodiment, the invention provide a fertilizer production arrangement, wherein the ammonia condenser arrangement comprises
a. a first electrode, arranged to generate a corona discharge, and a second electrode comprising an haze-permeable electrically conductive sieve of a plurality of conductive strands;

b. a liquid atomizer arranged to atomize a liquid to providing a liquid haze between the first and the second electrode;

c. a substrate, arranged, relative to the first electrode, behind the second electrode; and

d. a collector, configured to collect aqueous liquid formed at the substrate as ammonia containing aqueous liquid.

The contacting unit may in an embodiment comprise a mixer. Hence, such contacting unit may especially be configured to mix the ammonia containing aqueous liquid and the polysaccharide containing waste product.

In another embodiment, the contacting unit may comprise a filter, configured to host the waste product. Such embodiment may be used to add the ammonia containing aqueous liquid to the polysaccharide containing waste product in the filter, whereby ammonia enriched polysaccharide containing waste product may reside on the filter and ammonia depleted liquid may escape from the filter. As mentioned above, the ammonia depleted liquid may, after separation, be contacted again with the ammonia enriched polysaccharide containing waste product (on the filter). Optionally this may be repeated one or more times.

The polysaccharide waste product might also be brought directly in contact with the ammonia in one vessel, tank or the like, where it is allowed to be removed from the aqueous liquid by reaction with the polysaccharide. Here, contacting may include mixing, such as by stirring. However, also other methods known in the art to contact liquid and solid materials may be applied.

In yet a further aspect, the invention provides an accommodation arrangement comprising an accommodation, especially selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm, and a fertilizer production arrangement as described herein. The accommodation arrangement is configured to provide at least part from the air containing ammonia from the accommodation to the fertilizer production arrangement, which converts at least of the ammonia into fertilizer material, as described above.
Specific embodiments

Specific, non-limiting, embodiments in relation to the contacting of at least part of the air with the aqueous liquid, wherein the aqueous liquid is a solvent for ammonia, to provide an ammonia containing aqueous liquid and/or of the ammonia condenser arrangement, are described below.

It is further an aspect of the invention to provide a method for the removal of a gaseous fluid (especially NH$_3$) comprising:

a. applying an electric field between a first electrode arranged to generate a corona discharge and a second electrode comprising an haze-permeable electrically conductive sieve (also indicated as “conductive sieve” or “haze-permeable conductive sieve”) of a plurality of conductive strands;

b. atomizing a liquid to providing a liquid haze between the first and the second electrode, wherein the liquid is a solvent for the gaseous fluid; and

c. arranging a substrate behind, relative to the first electrode, the second electrode.

This method is a specific embodiment that can be implemented as the part of the invention that is directed to the removal of ammonia from air”, such as comprised by “contacting at least part of the air with an aqueous liquid, wherein the aqueous liquid is a solvent for ammonia, to provide an ammonia containing aqueous liquid”.

The part of an embodiment of the invention uses the principles that the undesired gaseous fluid(s) may be at least partially solved in the liquid particles in the haze, and the fact that the electrode(s) create a kind of an “electric wind” and an electric charging of the liquid droplets of the haze, which will be directed by the “electric wind” due to the electric field between the electric source (first electrode) and the counter electrode (second electrode). The droplets are guided in the direction of the second electrode, which is haze permeable and which allows permeation of at least part of the haze, in a direction to the substrate, at which the droplets may deposit. At the substrate, collection of the undesired gaseous fluid, solved in the liquid of the haze, may take place.

For instance, in water solved ammonia may be collected at the substrate, and may in principle be reused. Hence, in an embodiment, the gaseous fluid is ammonia (NH$_3$) and the liquid is water. In a relatively easy way, an undesired gaseous fluid may be removed. The method may be applied in existing accommodations such as a shed, a stable, a sty, a fold, or a poultry farm. The term “accommodation” may relate to any
cage, stable, shed, sty, fold, and also farm, for hosting one or more animals, especially a plurality of animals, such as pigs, cows, horses, goats, pigeons, birdhouse birds, tropical birds, gooses, mink animals or fir animals. The method may be applied within such building, or a unit (comprising an arrangement, see below), may be provided to which the air of the building is guided for treatment according to the invention. The phrase “method for the removal” includes a partial removal and does not necessarily indicate a total removal. However, the unit may for instance also be used to abate undesired gasses from for instance a laboratory, a plant, hospitality areas, etc.

Hence, to provide the effect of the invention, two electrodes are arranged, an electric field is applied, a liquid haze is provided between the two electrodes, and droplets, scavenging undesired gaseous fluids, may migrate to a negatively charged or grounded electrode. Especially when such electrode is permeable to air, even more permeable to a substantial part of the liquid haze droplets, such haze may travel “through” the permeable electrode, and at least partially be collected at the substrate, arranged downstream of the (second) electrode. The electric field is especially enforced by charged needle points, or line arranged constructions, and/or wires of the first electrode, which may generate corona discharges, which appears to be helpful in generating the electronic wind.

The electrodes are arranged in a space that contains or is able to contain a gas comprising the gaseous fluid. For instance, the electrodes may be arranged in a shed or another accommodation. Preferably, the electrodes are arranged at distances from each other such that a substantial part of the space is bridged with the electric field between the electrodes. As mentioned above, the electrodes may also be arranged in a (separate) unit, arranged to receive the gaseous fluid.

The electric field is especially in the range of about 0.1-100 kV/m. In a specific embodiment, the electric field is in the range of about 0.5-100 kV/m, even more especially in the range of about 2-100 kV/m, yet even more especially in the range of about 4-100 kV/m. Especially, the electric field may be smaller than about 50 kV/m, more especially smaller than 20 kV/m. The electric field is applied between a first electrode, especially being a positive electrode arranged to generate a corona discharge, and a second electrode, especially being an earthed electrode.

Preferably, the first electrode may comprise a plurality of conductive needles (herein also indicated as “needles”). Such first electrode comprising a plurality of
needles may also be indicated as first electrode comprising a plurality of electrodes, since the plurality of needles are conductive needles, and thereby electrodes. Especially, the method further may further comprise arranging the plurality of conductive needles to point in the direction of the second electrode. Hence, in an embodiment, the plurality of conductive needles are arranged to point in the direction of the second electrode.

Preferably, the second electrode comprises an haze-permeable electrically conductive sieve (also indicated as “conductive sieve” or “haze-permeable conductive sieve”) of preferably a haze-permeable electrically conductive sieve of a plurality of conductive strands. In an embodiment, the second electrode may comprise an haze-permeable electrically conductive sieve of a plurality of conductive strands having a shortest distance between adjacent conductive strands in the range of 0.01-1000 mm, such as 0.01-500 mm, like 0.1-1000 mm, such as 0.1-500 mm, especially at least 1 mm, like 1-500 mm, even more especially 1-100 mm, like 5-100 mm, such as at least 10 mm. In a specific embodiment, the second electrode comprises a plurality of conductive wires, preferably arranged substantially parallel to each other), especially a conductive wire gauze (i.e. conductive gauze).

The phrase “applying an electric field to the gaseous fluid” may indicate that an electric field is applied in a space where the gaseous fluid is present, such as in a room or a shed, etc.

The term “corona discharge” is known in the art. A corona is a process by which a current, perhaps sustained, develops from an electrode with a high potential in a neutral fluid, usually air, by ionizing that fluid so as to create a plasma around the electrode. The ions generated eventually pass charge to nearby areas of lower potential, or recombine to form neutral gas molecules. When the potential gradient is large enough at a point in the fluid, the fluid at that point ionizes and it becomes conductive. If a charged object has a sharp point, the air around that point will be at a much higher gradient than elsewhere. Air (or another gas) near the electrode can become ionized (partially conductive), while regions more distant do not. When the air near the point becomes conductive, it has the effect of increasing the apparent size of the conductor. Since the new conductive region is less sharp (or curved), the ionization may not extend past this local region. Outside of this region of ionization and conductivity, the charged particles slowly find their way to an oppositely charged object and are
neutralized. If the geometry and gradient are such that the ionized region continues to grow instead of stopping at a certain radius, a completely conductive path may be formed, resulting in a momentary spark, or a continuous arc. Corona discharge usually involves two asymmetric electrodes; one highly curved (such as the tip of a needle, or a small diameter wire) and one of low curvature (such as a plate, or the ground, or the herein indicated gauze). The high curvature ensures a high potential gradient around one electrode, for the generation of a plasma.

Electric charges on conductors reside entirely on their external surface (see Faraday cage), and tend to concentrate more around sharp points and edges than on flat surfaces. This means that the electric field generated by charges on a curved conductive point is much stronger than the field generated by the same charge residing on a large smooth spherical conductive shell. When this electric field strength exceeds what is known as the corona discharge inception voltage (CIV) gradient, it ionizes the air about the tip, and a small faint purple jet of plasma can be seen in the dark on the conductive tip. Ionization of the nearby air molecules result in generation of ionized air molecules having the same polarity as that of the charged tip. Subsequently, the tip repels the like-charged ion cloud, and the ion cloud immediately expands due to the repulsion between the ions themselves. This repulsion of ions creates an “electric wind” that emanates from the tip.

The term “haze permeable” especially indicates that the haze may pass through the “sieve”, especially at least part of the total number of droplets haze droplets arriving at the second electrode may penetrate through the openings or meshes between the conductive strands. In this way, the haze may be directed in a direction from the first electrode to the second electrode, “pass” the second electrode and be collected at the substrate, arranged downstream from the second electrode. The phrase, “behind the second electrode, relative to the first electrode” and similar phrases indicate that the substrate is arranged downstream of the second electrode.

The terms “upstream” and “downstream” relate to an arrangement of items or features relative to the propagation or flow of the electronic wind from a first electrode, wherein relative to a first position within the flow, a second position in the flow closer to the first electrode is “upstream”, and a third position within the flow further away from the first electrode is “downstream”. Hence, the first electrode is arranged
upstream of the second electrode; the second electrode is arranged downstream of the first electrode, but arranged upstream of the substrate.

The phrase “atomizing a liquid” indicates that a liquid is at least partly transferred into (small) liquid droplets in the gaseous state, such as with steam, or a haze, or mist. The atomized liquid is herein indicated as “haze”. The liquid atomizer relates to an apparatus or device that is able to atomize a liquid, i.e. provide liquid droplets in the gaseous state. Examples of atomizers are for instance an apparatus for boiling the liquid, or an ultra sonic haze generator, a (high) pressure atomizer, an electro spray, etc. The term “liquid atomizer” may in an embodiment refer to a plurality of liquid atomizers.

The haze is a solvent for the gaseous fluid. This may indicate that at least part of the gaseous fluid may be solved in the liquid droplets of the haze. An example may be ammonia gas that may be solved in water droplets. Another example of a gaseous fluid may be acetone (C\textsubscript{3}H\textsubscript{6}O), dinitrogen oxide (N\textsubscript{2}O), hydrogen sulphide (H\textsubscript{2}S), ethylene (C\textsubscript{2}H\textsubscript{4}), fluor (F\textsubscript{2}) or chlorine (Cl\textsubscript{2}). Other gaseous fluids may comprise gaseous hydrocarbons. Depending upon the gaseous fluid to be abated, also other liquids may be applied. For instance, the liquid may be chosen from the group comprising water, alcohol and also acetone. Acetone may be applied where for instance hydrocarbons (not acetone) is to be removed. This may especially be applied in a closed unit (see also below). The gaseous fluid is in general not a pure gas, but is in general present in another gas, such as air.

In a specific embodiment, the substrate is a cloth. Further, the substrate may be a lamellar cloth, or a (metal) gauze. In an embodiment, the substrate is also gas permeable. This means that at least part of the gaseous fluid and/or air, may also travel through the substrate. This may further facilitate a smooth flow of the gaseous fluid and air.

Especially, the substrate may be air-permeable, i.e. it may comprise openings or meshes through which air and/or the gaseous fluid may travel. The term “air permeable” especially indicates that air may pass through the substrate, especially at least part of the gaseous fluid may penetrate through the openings or meshes. In this way, the haze may be directed in a direction from the first electrode to the second electrode, “pass” the second electrode and be collected at the substrate, arranged downstream from the second electrode. The substrate may have openings with
dimensions (such as length, width or diameter) similar as those of the second electrode, such as in the range of 0.01-1000 mm, such as 0.01-500 mm, like 0.1-1000 mm, especially at least 1 mm, like 1-500 mm, even more especially 1-100 mm, like 5-100 mm, but preferably the dimensions are smaller, like in the range of 0.01-500 mm, such as 0.01-200 mm, like 0.1-200, such as 0.1-100 mm.

In a specific embodiment, the substrate is at least temporarily wetted with a liquid, preferably the same liquid as used to atomize, by an auxiliary moistener. In this way, the substrate may be maintained in a wet state, which may improve capture of the haze droplets. The term “auxiliary moistener” or shortly “moistener” is used to indicate a device that is arranged to moisten the substrate (i.e. at least part of the substrate), and which is different from the atomizer that is used to provide the liquid haze, and which haze may also moisten the substrate. In an embodiment, the method further comprises collecting liquid formed (deposited) at the substrate and removing the collected liquid.

In a further aspect, the invention provides an arrangement for removing a gaseous fluid comprising:

a. a first electrode, arranged to generate a corona discharge, and a second electrode comprising an haze-permeable electrically conductive sieve of a plurality of conductive strands;

b. a liquid atomizer arranged to atomize a liquid to providing a liquid haze between the first and the second electrode; and

c. a substrate, arranged, relative to the first electrode, behind the second electrode.

Such arrangement may be arranged in an accommodation, such as a shed, a stable, a sty, a fold, or a poultry farm, but such arrangement may also be included in a separate unit, which may be arranged in gaseous contact with the air in the accommodation, for treatment of the air. Hence, in an embodiment the arrangement is comprised in a unit, having an inlet, arranged to allow the gaseous fluid enter the unit and an outlet, arranged to allow one or more of gas and liquid escape from the unit. The arrangement may further comprising one or more of a blower, arranged to blow gaseous fluid into the unit, and a pump, arranged to pump gas fluid into the unit. As will be clear to the person skilled in the art, one or more blowers and/or one or more pumps may be applied. The term “treatment” indicates the method for the removal.
In a specific embodiment, the arrangement further comprises an auxiliary moistener, arranged to wet the substrate.

As mentioned above, the first electrode preferably comprises a plurality of conductive needles. In an embodiment, the plurality of conductive needles are arranged to point in the direction of the second electrode. The haze-permeable electrically conductive sieve is in an embodiment a conductive wire gauze.

The first electrode and the second electrode are arranged at a non-zero distance, such as for instance in the range of 0.05-500 m, like 2-25 m.

In a further aspect, the invention provides an accommodation, especially for animals, comprising the arrangement. The arrangement may be included in the accommodation or may be in gaseous contact with the accommodation, but arranged outside of the accommodation, such as a separate unit arranged to treat the gas comprising the gaseous fluid, such as air comprising NH₃, within the accommodation. In an embodiment, the accommodation may be selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm. Alternatively, the accommodation may for instance be selected from the group consisting of a laboratory, a plant and a hospitality area.

It further advantageously appears that the number of dust / small particles is reduced. Hence, the method and arrangement of the invention may be used to simultaneously reduce (abate) a gaseous fluid and small particles.

*Further specific embodiments*

Further specific embodiments are elucidated below, with numbers only for reference purposes:

1. A method embodiment for the removal of ammonia from air and converting the ammonia in a fertilizer material, comprising:
   a. contacting at least part of the air with an aqueous liquid, wherein the aqueous liquid is a solvent for ammonia, to provide an ammonia containing aqueous liquid; and
   b. contacting the ammonia containing aqueous liquid with a polysaccharide containing waste product.

2. The method embodiment according to method embodiment 1, wherein the aqueous liquid comprises water.
3. The method embodiment according to any one of method embodiments 1-2, further comprising separating the with ammonia enriched polysaccharide containing waste product as fertilizer material from the ammonia depleted liquid.

4. The method embodiment according to method embodiment 3, wherein the ammonia depleted liquid after separation is contacted with the ammonia enriched polysaccharide containing waste product, and optionally repeating this one or more times.

5. The method embodiment according to any one of method embodiments 1-4, wherein the polysaccharide containing waste product comprises a product selected from the group consisting of fruit, vegetable, and vegetation.

6. The method embodiment according to any one of method embodiments 1-5, wherein the polysaccharide containing waste product comprises a product selected from the group consisting of organic litter and manure.

7. The method embodiment according to any one of method embodiments 1-6, wherein the polysaccharide containing waste product comprises a food residue.

8. The method embodiment according to any one of method embodiments 1-7, wherein the method embodiment comprises atomizing the aqueous liquid to provide an aqueous liquid haze, contacting at least part of the air with the aqueous liquid haze, and condensing at least part thereof to provide the ammonia containing aqueous liquid.

9. The method embodiment according to any one of method embodiments 1-8, wherein the method embodiment comprises mixing at least part of the air and the aqueous liquid to provide the ammonia containing aqueous liquid.

10. The method embodiment according to any one of method embodiments 1-9, comprising:

   a. applying an electric field between a first electrode arranged to generate a corona discharge and a second electrode, comprising an haze-permeable electrically conductive sieve of a plurality of conductive strands;

   b. atomizing the aqueous liquid to provide a aqueous liquid haze between the first and the second electrode;

   c. arranging a substrate behind, relative to the first electrode, the second electrode;

   d. collecting aqueous liquid formed at the substrate as ammonia containing aqueous liquid; and
c. contacting the ammonia containing liquid with a polysaccharide containing waste product.

11. The method embodiment according to any one of method embodiments 1-10, for the removal of ammonia from air in an accommodation, wherein the accommodation is selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm.

12. A method embodiment for the production of a fertilizer material comprising mixing an ammonia containing liquid with a polysaccharide containing waste product.

13. The method embodiment according to method embodiment 12, further comprising separating the with ammonia enriched polysaccharide containing waste product as fertilizer material from the ammonia depleted liquid.

14. The method embodiment according to method embodiment 13, wherein the ammonia depleted liquid after separation is contacted with the ammonia enriched polysaccharide containing waste product, and optionally repeating this one or more times.

15. The method embodiment according to any one of method embodiments 12-14, wherein the ammonia containing liquid is an ammonia containing aqueous liquid, especially ammonia containing water.

16. The method embodiment according to any one of method embodiments 12-15, wherein the polysaccharide containing waste product comprises a product selected from the group consisting of fruit, vegetable, and vegetation.

17. The method embodiment according to any one of method embodiments 12-16, wherein the polysaccharide containing waste product comprises a product selected from the group consisting of organic litter and manure.

18. The method embodiment according to any one of method embodiments 12-17, wherein the polysaccharide containing waste product comprises a food residue.

19. The method embodiment according to any one of method embodiments 1-18, wherein the method embodiment further comprises adding one or more of P-containing material and K-containing material, and optionally also adding one or more of Ca-containing material, Mg-containing material, Fe-containing material and I-containing material.
20. The method embodiment according to any one of method embodiments 1-19, wherein the polysaccharide containing product comprises a cellulose containing product.

21. A fertilizer production arrangement embodiment comprising (1) an ammonia condenser arrangement embodiment, configured to remove ammonia from a gas and to provide an ammonia containing aqueous liquid, and (2) a contacting unit, configured to contact the ammonia containing aqueous liquid with a polysaccharide containing waste product.

22. The fertilizer production arrangement embodiment according to arrangement embodiment 21, wherein the contacting unit comprises a mixer.

23. The fertilizer production arrangement embodiment according to any one of arrangement embodiments 21-22, wherein the contacting unit comprises a filter, configured to host the waste product.

24. The fertilizer production arrangement embodiment according to any one of arrangement embodiments 21-23, wherein the ammonia condenser arrangement embodiment comprises a liquid atomizer, configured to atomize the aqueous liquid to provide an aqueous liquid haze.

25. The fertilizer production arrangement embodiment according to any one of arrangement embodiments 21-24, wherein the ammonia condenser arrangement embodiment comprise a gas-liquid mixer, configured to mix the aqueous liquid and the air containing ammonia.

26. The fertilizer production arrangement embodiment according to any one of arrangement embodiments 21-25, wherein the ammonia condenser arrangement embodiment comprises

   a. a first electrode, arranged to generate a corona discharge, and a second electrode comprising an haze-permeable electrically conductive sieve of a plurality of conductive strands;

   b. a liquid atomizer arranged to atomize a liquid to providing a liquid haze between the first and the second electrode;

   c. a substrate, arranged, relative to the first electrode, behind the second electrode; and

   d. a collector, configured to collect aqueous liquid formed at the substrate as ammonia containing aqueous liquid.
27. An accommodation arrangement comprising an accommodation, selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm, and a fertilizer production arrangement according to any one of arrangement embodiments 21-26.

The term “substantially” herein, such as in “substantially consists”, will be understood by the person skilled in the art. The term “substantially” may also include embodiments with “entirely”, “completely”, “all”, etc. Hence, in embodiments the adjective substantially may also be removed. Where applicable, the term “substantially” may also relate to 90% or higher, such as 95% or higher, especially 99% or higher, even more especially 99.5% or higher, including 100%. The term “comprise” includes also embodiments wherein the term “comprises” means “consists of”.

Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

The devices herein are amongst others described during operation. As will be clear to the person skilled in the art, the invention is not limited to methods of operation or devices in operation.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "to comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in
mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

**Brief description of the drawings**

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, and in which:

- Figures 1a-11h schematically depict some embodiments and arrangements of the invention and further elucidates the method of the invention;
- Figures 2a-2b schematically depict some embodiments of the invention;
- Figures 3a-3d schematically depict some variants of the first and second electrode;
- Figures 4a-4b schematically depict some variants of the substrate;
- Figures 5a-5c schematically depict some principles of the method; and
- Figure 6 schematically depicts an embodiment of the invention, wherein the arrangement is external from an accommodation for animals.

The drawings are not necessarily on scale. The invention is not limited to the presence of animals, nor limited to the specific animals depicted.

**Description of preferred embodiments**

Figure 1a schematically depicts some routes within the method of the invention. Air 510 and an aqueous liquid 520 are contacted to provide an ammonia containing aqueous liquid 530. The ammonia containing aqueous liquid 530 and a polysaccharide containing waste product 570 are contacted to provide the fertilizer material 540. Optionally, the combination of the ammonia containing aqueous liquid 530 and the polysaccharide containing waste product 570 may not only lead to fertilizer material 540 but may also lead to waste material 550 (such as ammonia depleted aqueous liquid), which may optionally be contacted again with the ammonia enriched waste product (for the sake of understanding here indicated as fertilizer material 540). The optional contacting is indicated with reference 560.

Figure 1b schematically depicts an embodiment of a fertilizer production arrangement 600 comprising (1) an ammonia condenser arrangement 610, configured to remove ammonia from the gas 510 and to provide the ammonia containing aqueous
liquid 530 and (2) a contacting unit 620, configured to contact the ammonia containing aqueous liquid 530 with the polysaccharide containing waste product 570. The condenser arrangement 610 and the contacting unit 620 are in liquid contact with each other via tube or conduit 530, for instance to transport the ammonia containing aqueous liquid 530 to the contacting unit 620. With the latter, the fertilizer material 540 is produced, and optionally residual material 550 is produced. For instance, residual material 550 might comprise remaining ammonia depleted ammonia containing aqueous liquid. The ammonia containing aqueous liquid 530 may be depleted to such an extent in ammonia, that the liquid may be reused, for instance as potable water.

Figure 1c schematically depicts an embodiment of the contacting unit 620, wherein the contacting unit comprises a filter 621. The filter is arranged to host the polysaccharide containing waste product 570. Ammonia containing aqueous liquid 530 may be poured on the polysaccharide containing waste product 570 (thereby contacting both materials with each other), thereby providing, after one or more contacts fertilizer material. Liquid escaping from the filter is indicated with reference 531, which refers to ammonia depleted ammonia containing aqueous liquid. As mentioned above, this may be used for one or further filtrations, until the desired depletion and/or the desired enrichment is obtained.

Figure 1d schematically depicts an embodiment of the contacting unit 620, wherein the contacting unit comprises a mixer unit 621, comprising a vessel or container and a mixing device. The polysaccharide containing waste product 570 and ammonia containing aqueous liquid 530 may be mixed in this way. Other contacting options are however also possible.

Figure 1e schematically depicts an embodiment of the condenser arrangement 610, wherein the condenser arrangement comprises a vessel or container, configured to host the aqueous liquid 520, and configured to allow introduction of the air with ammonia under the liquid surface of the aqueous liquid 520 (“bubbling”). After the desired uptake of ammonia, the ammonia containing aqueous liquid is obtained.

Figure 1f schematically depicts an embodiment of the condenser arrangement 610, wherein the condenser arrangement comprises scrubber. Air is provided within the scrubber and the aqueous liquid 520 drops down, thereby scavenging part of the ammonia in the air. Aqueous liquid 520 may be reused, until the desired uptake of
ammonia is obtained. After the desired uptake of ammonia, the ammonia containing aqueous liquid is obtained.

Figure 1g schematically depicts an embodiment of the condenser arrangement 610, where an (aqueous) liquid atomizer 150 is used to provide an atomized (aqueous) liquid or haze 160. This haze, or more especially the droplets therein, scavenge ammonia from the air 510. Droplets may condense at a substrate and ammonia containing aqueous liquid 530 may be collected in a collector 611.

Figure 1h schematically depicts an embodiment of an accommodation arrangement 700 comprising an accommodation 100, such as selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm, and a fertilizer production arrangement 600, as described above, wherein the fertilizer production arrangement 600 is configured to remove ammonia from a gas from the accommodation.

Figures 2a and 2b schematically depict an accommodation 100 for animals 1, such as a cow, comprising an arrangement 10. The accommodation is for instance selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm. However, the method of the invention is not limited to such accommodations.

The arrangement 10 is used to remove a gaseous fluid. This may be a complete or partial removal. The removal may be performed in a batch or in a continuous process. For instance, the method of the invention (see also below), may be applied above a predetermined threshold value of a gaseous fluid. The gaseous fluid is indicated with reference 20 and is in general a component of air. For instance, air may comprise ammonia as gaseous fluid 20.

The arrangement 10 comprises a first electrode 110, arranged to generate a corona discharge and a second electrode 120 comprising an haze-permeable electrically conductive sieve of a plurality of conductive strands (see below). The arrangement 10 further comprises a liquid atomizer 150 arranged to atomize a liquid to providing a liquid haze 160 between the first and the second electrode. The arrangement 10 further comprises a substrate 130, arranged behind, relative to the first electrode 110, the second electrode 120.

The accommodation 100 has an internal space, indicated with reference 101, wherein the arrangement 10 is arranged. Further, one or more animals 1, such as one or more cows, may be present in the accommodation 100. With animal excretion and
production of faeces, the production of ammonia is concomitant. The presence of the undesired gaseous fluid, such as ammonia, is indicated with reference 20. The first electrode 110 and the second electrode 120 are arranged at a non-zero distance L1, such as for instance in the range of 0.05-500 m, like 2-500 m, such as especially 2-200 m, especially in the range of about 2-50 m, more especially in the range of about 5-25 m. Note that that there may be one first electrode 110 and a plurality of second electrodes 120, a plurality of first electrodes 110 and a plurality of second electrodes 120, and a plurality of first electrodes 110 and a plurality of second electrodes 120.

Here, the first electrode 110 may especially comprise a plurality of needles 115 with tips 116. The tips 116 are preferably directed to the second electrode 120. Hence, here the first electrode 110 comprises a plurality of conductive needles 115 and preferably, the plurality of conductive needles are arranged to point in the direction of the second electrode 120.

Preferably, the electrodes 110,120 are arranged in such a way, that they effectively span the internal space 101. The liquid atomizer 150 provides the haze 160 of droplets of a liquid. The gaseous fluid may at least partly be solved in the droplets. In this way the gaseous fluid may already be at least partly neutralized. However, due to the presence of the electric field, indicated with reference 30, the droplets are directed in a specific direction. Here, the corona discharges at the positively charged electrode propel the droplets, i.e. the haze 160, in the direction of the second electrode 120. The second electrode 120 may be negatively charged or may be grounded.

Since the second electrode 120 is permeable at least part of the haze 160 may travel through the second electrode 120 and may come into contact with the substrate 130. The substrate 130 is especially arranged to gather a substantial part of the droplets in the haze 160. Hence, the liquid condenses at the substrate 130 and may drip to the bottom, such as in a gutter 140. The collected liquid may be processed, for instance to separate the gaseous fluid component, such as ammonia from the liquid, where after the liquid may be reused and the gaseous fluid may be also be reused. For instance, ammonia may be used for fertilizer production.

Figure 2b schematically depicts an embodiment, wherein the accommodation 100 is divided in several parts, and a plurality of arrangements 10 is arranged in the internal space 101 of the accommodation 100.
The droplets of the haze, especially water droplets, will in general be in the order of about 0.01 μm - 3 mm, more especially about 0.1 μm – 3 mm, like 0.1 μm – 1 mm, like at least about 0.1 mm. Herein, the term conductive is known in the art, but especially refers to a resistivity of about $1.10^9$ Ω·m (at 20 °C) or less.

In fact, the arrangements 10 of schematic drawings 2a and 2b, may facilitate the production of ammonia (i.e., it is an embodiment of the condenser arrangement 610). Having collected ammonia containing aqueous liquid, such as in for instance the gutter 140, the collected ammonia may be provided to a contacting unit 620 (not depicted, but see for instance figures 1a-1g and 6).

With reference to also figures 3a-3d, some principles of the invention are further elucidated.

In a specific embodiment, the electric field is applied between a first electrode 110, especially arranged to generate a corona discharge and especially arranged to generate an electric field in the range of about 0.1-100 kV/m, and a second electrode 120, comprising a conductive wire, here especially comprising a conductive wire gauze 125. In an embodiment, the second electrode is earthed 121 (as depicted). However, in another embodiment, the second electrode 120 may be isolated and may be neutral or negatively charged. Especially in such embodiments, the first electrode 110 and the second electrode 120 are electrically connected, as indicated in the schematic figure 1a (and 1 b; left variant).

In general, the second electrode 120 comprises an haze-permeable electrically conductive sieve 200 (herein also indicated as “sieve”) of a plurality of conductive strands 201 (see also figure 3b). As will be clear to the person skilled in the art, the term “conductive sieve 200” and “conductive strands 201”, refer to electrically conductive sieve 200 and electrically conductive strand, respectively.

This especially means that a plurality of conductive strands 201, be it conductive wires, be it conductive bars, be it a conductive gauze, etc., which strands 201 may be regularly or irregularly arranged (or a combination thereof), form a kind of sieve, be it a 1D sieve (like a “comb”), a 2D sieve (like a gauze) or a 3D sieve (like a 3D gauze or 3D frame work of wires), with a shortest distance between adjacent conductive strands (see also below, which are large enough to allow air and fog pass through. Preferably, in a 1D sieve, the strands are arranged substantially parallel. In a 2D sieve, in an embodiment subsets of strands may be arranged substantially parallel, but the subsets
may be arranged under an angle. In yet another embodiment, the 2D sieve is arranged to provide square or rectangular meshes. In yet another embodiment, the 2D sieve is arranged to provide pentagonal, hexagonal, heptagonal or octagonal meshes, especially hexagonal meshes. Crossing strands may be knotted or fused. The person skilled in the art know types of different gauzes. 3D gauzes can be similar as 2D gauzes, but than in 3 directions.

The second electrode 120, especially the haze-permeable electrically conductive sieve 200, is a device having in an embodiment a substantially flat front (1D sieve or 2D sieve, etc.), formed by a plurality of strands 201, that is arranged to be directed to the first electrode 110. More especially, the curved features (see below) of the first electrode 110, such as the needles, substantially point in the direction of the second electrode 120, more especially the haze-permeable electrically conductive sieve 200. Preferably, the needles 115 of the first electrode 110 and the second electrode 120 are arranged to be perpendicular to each other (see also a number of accompanying drawings).

The electric field 30 is especially a static electric field. In a further embodiment, there may be a modulation on the electric field 30. Such modulation may be an on-off modulation, or may be a modulation on a constant value (for instance a sinusoidal modulation). However, the modulation is essentially not such, that the direction of the electric field 30 is inverted. Hence, referring to figures 1a/1b, although temporarily the first electrode 110 might be uncharged, when charged, the charge is especially positive.

In another specific embodiment, a shortest distance L1 between the first electrode 110 and the second electrode 120 is in the range of about 0.05-500 m. In figures 1a and 1b, the shortest distance is indicated with reference L1. Especially, the shortest distance between the first electrode 110 and the second electrode 120 in such configuration in a shed, etc. may be in the range of about 2-100 m, such as 2-50 m, especially 2-25 m, and in an embodiment 5-25m.

Figures 2a/2b could for instance include one gauze 125 as second electrode 120; however, as will be clear to the person skilled in the art, a plurality of gauzes 125 may be applied; i.e. the arrangement 100 may comprise a plurality of second electrodes 120, especially a plurality of conductive gauzes 125. As mentioned above, these gauzes 125 may be arranged in an isolated way (i.e. not grounded). Thus, the haze-permeable electrically conductive sieve 200 here comprises a gauze 125. The schematic drawing
depicts a 2D arrangement of conductive strands 201. The schematic drawing shows a subset of substantially parallel strands 201 and perpendicular thereto another subset of substantially parallel strands 201. The distances between substantially parallel strands (i.e. d2 and d3, see below), such as wires or bars, or the maze of the gauze 125, which may be used as second electrode 120, may especially between 0.01-1000 mm, such as about 0.1-500 mm, like in the range of 1-100 mm.

In a specific embodiment, the first electrode 110 comprises a plurality of electrodes, such as a plurality of electrically conductive needles, wherein the plurality of electrodes are arranged to generate corona discharges. In figure 3a, the plurality of electrodes is schematically with reference numbers 110a, 110b, 110c...

In a preferred embodiment, the first electrode 110 comprises one or more conductive curved features or conductive needles (indicated with reference 115) having one or more dimensions in the range of for instance about 0.1 μm – 0.5 mm. The curved feature may for instance comprise a wire, a wire mesh, an antenna or a needle, especially with the above defined dimensions. Especially needle like features are applied. Conductive needles are herein further indicated as needles. Needles are especially conductive protrusions or pins having mean aspect ratio’s (mean: i.e. mean over the length of the needle) in the range of about 5-2000 (i.e. length/(mean thickness or mean diameter)), especially 10-2000, even more especially 20-2000. Hence, in a specific embodiment, the first electrode 110 comprises one or more, especially a plurality, such as 4-10,000, curved features 115, especially needles. The curved features 115, especially the needles, may have one or more dimensions, i.e. especially thickness, in the range of about 0.1 μm – 0.5 mm, especially 1 μm – 0.5 mm, more especially 10 μm – 0.5 mm, even more especially 100 μm – 0.5 mm, such as 10 μm - 0.1 mm. Hence, the first electrode 110 especially comprises sharp points or needles. In general, the sharper the needle, the better.

In the figures, the curved features 115 are indicated as (sharp) needles, although also wires (optionally including cables), a wire gauze, etc. could be used. It is preferred the curved features have one or more dimensions in the range of about 0.1 μm – 0.5 mm, which dimensions allow corona discharges. In figure 3a, curved features 115 are indicated, which have a dimensions d1 (here thickness or diameter). Here, the one or more dimensions might be diameter or thickness. The length of such curved features 115 (e.g. needle length; i.e. longitudinal length) may especially be in the range of about
0.5 mm - 100 cm, especially in the range of about 5 mm -50 cm. Such curved features 115 may have angles of 140° or less, especially 90° or less, even more especially, 50° or less. These angles are in the schematic embodiment of figure 3a indicated with reference α. Especially preferred angles α are in the range of about 5-140°, more especially in the range of about 5-90°, yet even more especially in the range of about 5-50°, or even smaller. The tips of the curved features 115, here especially the tips of the needles, are indicated with reference number 116.

Hence, the figures also schematically show an embodiment of the arrangement 100, wherein the first electrode 110 comprises a plurality of conductive needles. Especially, the plurality of conductive needles are arranged to point in the direction of the second electrode 120 (as for instance shown in figures 1a and 1b).

In this way, a kind of electronic wind may be generated. This “electric wind” is especially directed in the direction of the second electrode 120. Hence, even if grounded, the electric wind may be directed to the second electrode 120. The second electrode 120 is especially an electrode that allows further propagation of the droplets to the substrate 130. Hence, the second electrode 120 is especially in an embodiment a wire, more especially a plurality of wires or bars, which are arranged substantially parallel, like a 1D raster, or a plurality of wires or bars arranged as a gauze 125 (which may be indicated as 2D raster).

As mentioned above, the “electric wind” is especially directed in the direction of the second electrode 120. Hence, in a specific embodiment, the first electrode 110 and the second electrode 120 are arranged to generate an electric wind in the direction of the second electrode 120. Amongst other, this may be done by providing an isolated second electrode 120 with especially a negative charge (during use of the arrangement 100). Further, this might also be done by directing the curved features 115, especially the needles, in the direction of the second electrode 120.

Herein, in an embodiment, the term “wire” or “conductive wire” may also relate to “cable” or “conductive cable”, respectively.

In a specific embodiment, the electrically conductive haze-permeable electrically conductive sieve 200, such as in an embodiment the wire gauze 125 comprises meshes with one or more dimensions (such as length, width or diameter) in the range of about 0.01-1000 mm, such as preferably 0.1-1000 mm, especially in the range of about 0.1-500 mm, even more especially 1 mm up to 100 mm. These dimensions let the fluid 20
pass through the sieve 200, and allow the droplets accumulate at the conductive strands 201. The dimensions are schematically depicted in figure 3b, wherein d2 and d3 indicate distances between neighbouring (i.e. adjacent) wires (i.e. the length and width), indicate with reference 126, gauze 125. Yet in another embodiment, the second electrode 120 comprises a plurality of conductive wires (including cables) which are arranged substantially parallel, and the distance between the wires is in the range of about 0.01-1000 mm, such as 0.1-1000 mm, especially in the range of about 0.1-500 mm (even more especially 1 mm up to 100 mm). Herein, the term “plurality of wires” especially relate to about 4-500 of such wires. Such gauzes 125 or plurality of wires may effectively catch the droplets and scavenge the droplets from the gaseous fluid 20.

Hence, in a specific embodiment, wherein the second electrode 120 comprises a plurality of wires, be it arranged substantially parallel or be it arranged in a wire gauze, the longest distance between two adjacent substantially parallel arranged wires is preferably in the range of 0.01-1000 mm, especially 0.1-1000 mm, especially in the range of about 0.5-500 mm, such as especially 1-500 mm, such as especially about 5-100 mm.

Therefore, the second electrode comprises conductive strands, wherein a shortest distance between adjacent (substantially parallel arranged) strands is 0.01-1000 mm, especially 0.01-500 mm, even more especially 0.1-1000 mm, such as 1-500 mm, or 1-100 mm, preferably 5-100 mm.

In a 1D sieve, a shortest distance may be the shortest distance between two adjacent strands 201, such as indicated with d3 in figures 3b and 3c. In a 2D sieve, such as depicted in figure 3b, a shortest distance may be a diameter, but may also be a length and/or a width, i.e. d2 and d3, respectively. Preferably at least 1 of these distances fulfils the condition that the shortest distance between adjacent conductive strands is about 0.01-500 mm. It is not necessary that also the other distance fulfils this condition, although in a preferred embodiment, this is the case. Likewise, in a 3D sieve (not depicted) a shortest distance may be a diameter, but may also be a length and/or a width and/or a depth. Preferably at least 1 of these distances fulfils the condition that the shortest distance between adjacent conductive strands is about 0.01-1000 mm. It is not necessary that also the other distance fulfils this condition, although in a preferred embodiment, this is the case. Distances d1 and d2, etc. are especially shortest distances between substantially parallel arranged strands 201.
In systems wherein meshes are present, such as in 2D gauzes, such meshes may have any shape, and in such systems, as a shortest length between adjacent strands, the mesh diameter may be chosen.

The dimensions of the conductive strands 201, indicated with reference d4, which may, dependent upon the type of conductive strands 201 be the diameter, or the mean diameter, or the width(s), are preferably in the range of about 0.05-50 mm, especially in the range of about 1-20 mm.

In an embodiment, not depicted, the haze-permeable electrically conductive sieve comprises a plurality of substantially parallel arranged electrically conductive plates. Again, this may be a 1D arrangement or a 2D arrangement. The distances between substantially parallel plates (i.e. d2 and d3), or the maze of the “plate” gauze 125, which may be used as second electrode 120, may especially between 0.01-1000 mm, such as about 0.1-1000 mm. The invention is further herein described by using a plurality of strands.

Figure 3c schematically depicts a 1D (array) of conductive strands 201, arranged as a kind of fence, as sieve 200. The meshes are indicated with reference d3. The meshes may vary over the sieve 200. Figure 3d schematically depicts the field 30 when the second electrode 120 is absent (for example figure 3d) or present (2e). Especially when using a (positively) charged first electrode 110 and a counter electrode (second electrode 120) the advantages of the invention may be achieved.

Preferably, the needles (or other sharp feature containing conductive items) and second electrode, especially thus the haze-permeable electrically conductive sieve 200, are arranged perpendicular, in the sense that the (plurality of) electrode(s) point in the direction of the second electrode 120.

Figures 4a and 4b schematically depict embodiments of the substrate 130. For instance, in figure 1a the substrate 130 may comprise a cloth 131, at least partly arranged in a liquid reservoir 132 comprising liquid 133. Due to this arrangement, the liquid may 133 may wet at least part of the substrate 130. The fact that the substrate 130 is wetted is schematically shown by the drops 134, dripping from the substrate 130. Hence, in a specific embodiment, the substrate 130 is arranged to be wetted during use of the method of the invention. The wet surface may facilitate collecting the droplets of the haze 160. As will be clear to the person skilled in the art, instead of a cloth, also another substrate may be applied. An advantage of a cloth 131 may be that it may be at
least partially permeable to air or other gases comprising the gaseous fluid. Further, instead of this wetting method, also other wetting method may be applied. The moistener, here liquid reservoir 132 filled with liquid 133, is indicated with reference 137.

Figure 4b schematically depicts another embodiment, wherein the substrate is a kind of sieve, indicated with reference 135. Over the sieve, one or more moisteners 137, such as showers or sprinklers are provided, indicated with reference 135.

The substrate 130 may be permeable to the gaseous fluid, such as ammonia (in air). For instance, the substrate 130 may comprise a plurality of (substantially parallel) arranged strands, wires, or plates. Again, this may be a 1D arrangement or a 2D arrangement. The distances between substantially parallel plates (i.e. d12 and d13) may especially between 0.01-500 mm, such as about 0.1-100 mm.

Where applicable, the dimensions given for d2,d3, d12, d13 may also relate to diameter. Hence, these dimensions may also be interpreted as effective diameters.

Further, the second electrode 120 may also be used as directional electrode, since due to the presence of the second electrode 120, the fluid, or at least the charged droplets therein, are moved in the direction of the second electrode 120. Hence, the fluid may also penetrate the second electrode 120, and for instance, be received by the substrate 130 arranged to receive the charged droplets. Such substrate 130 may be a plate with a collector. An example thereof is schematically depicted in figure 5a, wherein the electronic wind may blow through the second electrode 120. Part of the droplets may accumulate at the second electrode 120, but part of it may also penetrate through the second electrode 120 and be accumulated at the substrate 130, with for instance collector 140, here in the form of a gutter.

The substrate 130 may thus especially be arranged gravity to collect the droplets from the haze. The droplets may aggregate or condense at the substrate, such as at wires, and fall by gravity, where the collector 140 collects the droplets. Collector 140 may for instance be a gutter or a drain.

Figure 5b schematically depicts preferred arrangements of the first and the second electrodes 110,120. The first electrode 110 comprises a plurality of needles as curved features 115. Note that the “curve features” may have sharp edges as tips. The term “curved feature” may especially indicate that surfaces merge together into a tip, such as in the case of a wedge or a needle. Especially needles are preferred. Such
needle may comprise a longitudinal axis or “needle axis”, which preferably point in the
direction of the second electrode 120. In figure 5b, the longitudinal axis is indicated
with reference 175. Relative to this longitudinal axis 175, in the direction of the tip 116,
a virtual cone can be construed, having a cone angle θ. The virtual cone is construed by
providing a surface having an angle θ relative to the longitudinal axis 175; a symmetric
cone will have an opening angel 2 θ. Here the phrase “arranging the curved features (or
needles) 115 in such a way that the tips 116 are aligned in the direction of the second
electrode 120”, and similar phrases, especially indicate that at least part of the second
electrode 120 will be arranged within this virtual cone of at least one of the needles.

Preferably, especially in the case of a plurality of needles, the cone angle θ is 30°, more
preferably 20°, more preferably 10°, even more preferably 5°. This means that within
the virtual cone having a cone angle of 10°, the second electrode will be found. In case
the second electrode 120 is arranged precisely opposite of the first electrode 110, the
longitudinal axis 175 will “ intercept” the second electrode. In figure 5b, a
“perpendicular” arrangement of the plurality of needles relative to the second
electrode, especially the electrically conductive air permeable sieve 200.

In the case of one single needle, θ may larger, but is preferably smaller than 90°.

Alternatively, see figure 5c, the curved features (or needles) needles 115 may
point in a direction with an angle θ1, relative to a horizontal 170 starting from the first
electrode 115 and extending to the second electrode 120; again, angle θ1 is preferably
in the range of 0-30°, more preferably 0-20°, more preferably 0-10°, even more
preferably 0-5°. In figure 5c, angle θ1 would be 0°.

Figure 6 schematically depicts an embodiment of an embodiment of an
accommodation 100, wherein the arrangement 10 is arranged external from the
accommodation, or at least arranged external from the part wherein the source of the
gaseous fluid 20, here animal(s) 1, is (are) located. The arrangement 10 may be
comprised by a unit 11, having an inlet 171, arranged to receive a gas comprising the
gaseous fluid. The accommodation 100 and unit 11 are arranged to allow the gaseous
fluid enter via inlet 171 into the unit comprising the arrangement 10. Further, the
accommodation and/or the unit may further comprise one or more pumps 181, and/or
one or more vents 180. By way of example, a variant is shown comprising vent 181,
and two pumps 181, but in principle one or more of these, or additional vents or pumps
may be present. A vent may be arranged to blow at least part of the gas comprising the
gaseous fluid into the unit 11 (via inlet 171); a pump 181 may be arranged to pump gas comprising the gaseous fluid 20 into the unit; a pump 181 may be arranged to pump gas out of the unit 11 via exhaust 172. Also in the latter variant, such pump may be used to pump gas into the unit 11 via inlet 171.

As mentioned above, the unit 11 may have an exhaust 172, which may exhaust gas (optionally comprising liquid droplets) and optionally liquid from the liquid haze. Liquid may also be exhausted separately, which is schematically indicated with an exhaust 173, which may especially be arranged to let liquid (from the liquid haze) escape, and optionally also in the liquid solved fluid from the gaseous fluid. In general, the unit 11 will have at least one inlet 171 and at least one outlet, wherein in between the arrangement 10 is arranged.

The shortest distance L1 between the first and the second electrode in a unit 11 may be smaller than in an accommodation 100, and may for instance be in the range of 0.05-5 m, like 0.05-2 m, such as 0.1-1 m.

Figure 6 is a specific embodiment of figure 1h.

In fact, the arrangements 10 of schematic drawings 2a and 2b, may facilitate the production of ammonia (i.e., it is an embodiment of the condenser arrangement 610). Having collected ammonia, such as in for instance the gutter 140, the collected ammonia may be exhausted or may be provided to a contacting unit 620 (see for instance also figures 1a-1g).

Example 1

Used coffee powder (referred to as coffee pulp) is used to adsorp/absorp ammonia so as to remove it from aqueous solution or mixtures. 20 grams of standard coffee powder is placed in a paper coffee filter (see Figure XX). Tap water is used to make coffee according to the usual recipe. The residual wet coffee powder, the coffee pulp, remains in the filter for further use. The mass then has increased to 38 grams, due to water uptake. A 350 mL ammonia solution with a pH of 9.2 was prepared. The pH was measured with a state-of-the-art pH meter. The concentration of the total nitrogen is then equal to about 4.6 $10^{-5}$ M due to both NH$_3$ and NH$_4^+$ in water according to the equilibrium constant 1.8 $10^{-5}$ M of the equilibrium equation below:

$$\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$$
This solution is then poured into the coffee pulp which was still in the paper filter. The pH of the solution, collected in a beaker glass and that passed the filter was measured again with the same pH meter. This process was repeated seven times with the same solution through the same coffee pulp. After each run, the pH was measured. The evolution of the pH is shown in the table below. After five runs, the pH has dropped almost to seven (7) meaning that the solution is neutral, and no ammonia is left. The concentrations of NH₃, NH₄⁺, OH⁻, and the total nitrogen containing species (total N) are also shown in the table below.

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<th>K</th>
<th>[NH₃]</th>
<th>Total N</th>
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</table>

Biomass typically contains 1/3, 1/3, 1/3 polysaccharide, hemicellulose and lignin. All of them are polysaccharides. When firing the coffee beans, the composition changes. The changes are often found in the chain length of the polysaccharide. Several polysaccharide dissolve to give the taste of the coffee. The amount of polysaccharide doesn’t change so much upon firing.

**Example 2**

2g of freshly mown grass was brought into a 350 mL solution of ammonia with a pH of 11.3. After stirring for 20 minutes the pH dropped to 10.7. The pH then did not drop anymore.
Claims

1. A method for the removal of ammonia from air and converting the ammonia in a fertilizer material, comprising:
   a. contacting at least part of the air with an aqueous liquid, wherein the aqueous liquid is a solvent for ammonia, to provide an ammonia containing aqueous liquid; and
   b. contacting the ammonia containing aqueous liquid with a polysaccharide containing waste product.

2. The method according to claim 1, wherein the aqueous liquid comprises water.

3. The method according to any one of claims 1-2, further comprising separating the with ammonia enriched polysaccharide containing waste product as fertilizer material from the ammonia depleted liquid.

4. The method according to claim 3, wherein the ammonia depleted liquid after separation is contacted with the ammonia enriched polysaccharide containing waste product, and optionally repeating this one or more times.

5. The method according to any one of claims 1-4, wherein the polysaccharide containing waste product comprises a product selected from the group consisting of fruit, vegetable, and vegetation.

6. The method according to any one of claims 1-5, wherein the polysaccharide containing waste product comprises a product selected from the group consisting of organic litter and manure.

7. The method according to any one of claims 1-6, wherein the polysaccharide containing waste product comprises a food residue.

8. The method according to any one of claims 1-7, wherein the method comprises atomizing the aqueous liquid to provide an aqueous liquid haze, contacting at least part of the air with the aqueous liquid haze, and condensing at least part thereof to provide the ammonia containing aqueous liquid.

9. The method according to any one of claims 1-8, wherein the method comprises mixing at least part of the air and the aqueous liquid to provide the ammonia containing aqueous liquid.

10. The method according to any one of claims 1-9, comprising:
a. applying an electric field between a first electrode arranged to generate a corona discharge and a second electrode, comprising an haze-permeable electrically conductive sieve of a plurality of conductive strands;

b. atomizing the aqueous liquid to provide a aqueous liquid haze between the first and the second electrode;

c. arranging a substrate behind, relative to the first electrode, the second electrode;

d. collecting aqueous liquid formed at the substrate as ammonia containing aqueous liquid; and

e. contacting the ammonia containing liquid with a polysaccharide containing waste product.

11. The method according to any one of claims 1-10, for the removal of ammonia from air in an accommodation, wherein the accommodation is selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm.

12. A method for the production of a fertilizer material comprising mixing an ammonia containing liquid with a polysaccharide containing waste product.

13. The method according to claim 12, further comprising separating the with ammonia enriched polysaccharide containing waste product as fertilizer material from the ammonia depleted liquid.

14. The method according to claim 13, wherein the ammonia depleted liquid after separation is contacted with the ammonia enriched polysaccharide containing waste product, and optionally repeating this one or more times.

15. The method according to any one of claims 12-14, wherein the ammonia containing liquid is an ammonia containing aqueous liquid, especially ammonia containing water.

16. The method according to any one of claims 12-15, wherein the polysaccharide containing waste product comprises a product selected from the group consisting of fruit, vegetable, and vegetation.

17. The method according to any one of claims 12-16, wherein the polysaccharide containing waste product comprises a product selected from the group consisting of organic litter and manure.

18. The method according to any one of claims 12-17, wherein the polysaccharide containing waste product comprises a food residue.
19. The method according to any one of claims 1-18, wherein the method further comprises adding one or more of P-containing material and K-containing material, and optionally also adding one of more of Ca-containing material, Mg-containing material, Fe-containing material and I-containing material.

20. The method according to any one of claims 1-19, wherein the polysaccharide containing product comprises a cellulose containing product.

21. A fertilizer production arrangement comprising (1) an ammonia condenser arrangement, configured to remove ammonia from a gas and to provide an ammonia containing aqueous liquid, and (2) a contacting unit, configured to contact the ammonia containing aqueous liquid with a polysaccharide containing waste product.

22. The fertilizer production arrangement according to claim 21, wherein the contacting unit comprises a mixer.

23. The fertilizer production arrangement according to any one of claims 21-22, wherein the contacting unit comprises a filter, configured to host the waste product.

24. The fertilizer production arrangement according to any one of claims 21-23, wherein the ammonia condenser arrangement comprises a liquid atomizer, configured to atomize the aqueous liquid to provide an aqueous liquid haze.

25. The fertilizer production arrangement according to any one of claims 21-24, wherein the ammonia condenser arrangement comprise a gas-liquid mixer, configured to mix the aqueous liquid and the air containing ammonia.

26. The fertilizer production arrangement according to any one of claims 21-25, wherein the ammonia condenser arrangement comprises
   a. a first electrode, arranged to generate a corona discharge, and a second electrode comprising an haze-permeable electrically conductive sieve of a plurality of conductive strands;
   b. a liquid atomizer arranged to atomize a liquid to providing a liquid haze between the first and the second electrode;
   c. a substrate, arranged, relative to the first electrode, behind the second electrode; and
   d. a collector, configured to collect aqueous liquid formed at the substrate as ammonia containing aqueous liquid.
27. An accommodation arrangement comprising an accommodation, selected from the group consisting of a shed, a stable, a sty, a fold, and a poultry farm, and a fertilizer production arrangement according to any one of claims 21-26.
Fig 1c

Fig 1d

Fig 1e

Fig 1f
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. C05C3/00 A01K1/00 B01D53/00 B01D53/32

ADD.

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)
B01D A01K C05C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, BIOSIS, COMPENDEX, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>NL 1 011 714 C2 (JOHANNES ANTONIUS MARIA VAN ZE [NL]) 3 October 2000 (2000-10-03) page 3, line 4 - line 19 page 3, line 30 - line 33 page 5, line 29 - page 6, line 16 -----</td>
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X Further documents are listed in the continuation of Box C. X See patent family annex.

* 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 document 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

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Date of the actual completion of the international search: 16 September 2011

Date of mailing of the international search report: 26/09/2011

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2
NL 2280 HV Rijswijk
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Fax. (+31-70) 340-3016

Authorized officer

Rodriguez Fontao, M
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<td>NL 9 200 763 A (DOMINICUS MARinus JOHANNes DE) 16 November 1992 (1992-11-16) page 2, line 5 - page 4, line 8 claims 1-3,9</td>
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<td>EP 1 066 752 A1 (NIEMEIJER JOHANNes ANTONIUS [NL]; NIEMEIJER GERARDUS JOHANNES TI [NL]) 10 January 2001 (2001-01-10) claims; figures</td>
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