(19) Octrooicentrum Nederland

(11) 2016574

(12) A **OCTROOIAANVRAAG**

(21) Aanvraagnummer: **2016574**

(22) Aanvraag ingediend: **08/04/2016**

(51) Int. Cl.:
F24F 5/00 (2016.01) **F24F 3/14** (2016.01) **A01G 9/24** (2016.01)

(41) Aanvraag ingeschreven:
16/10/2017

(43) Aanvraag gepubliceerd:
20/10/2017

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(54) **Process to reduce the temperature of a feed of air and greenhouse.**

(57) Process to reduce the temperature of a feed of air by (a) contacting the feed of air with liquid water wherein part of the water evaporates to obtain air with a higher humidity and a reduced temperature. The air obtained in step (a) is contacted in step (b) with an aqueous hygroscopic solution to obtain air with a reduced humidity. In a step (c) the air obtained in step (b) is contacted with liquid water wherein part of the water evaporates to obtain air with a reduced temperature as compared to the air obtained in step (a). In a step (d) the water diluted hygroscopic solution obtained in step (b) is concentrated and cooled to obtained a concentrated and cooled hygroscopic solution which solution is used as the aqueous hygroscopic solution or as part of the aqueous hygroscopic solution in step (b).

PROCESS TO REDUCE THE TEMPERATURE OF A FEED OF AIR AND GREENHOUSE

The invention is directed to a process to reduce the temperature of a feed of air and directed to a greenhouse comprising numerous parallel and substantially horizontal oriented air distribution tubes and a cooling section.

Semi-closed greenhouses are described in 1992 in an article titled Verdampingskoeling voor tuinbouwkassen (Evaporative cooling for greenhouses) by Van Paassen, A.H.C. et al in Klimaatbeheersing 21 pp 165-172 (1992). In such a greenhouse ambient air, recycle air from within the greenhouse or their mixtures is distributed via numerous parallel oriented ventilation tubes to the greenhouse. The term semi-closed refers to the fact that ambient air may be provided to the greenhouse which greenhouse is also equipped to only or partly recycle a large portion of its own air. The ventilation tubes are positioned parallel below the cultivation. The air is cooled by injection of liquid water into the ventilation tubes. Examples of semi-closed greenhouses are described in WO2004/032606, EP1464219 and WO2008/002686. Various semi-closed greenhouses have been build and successfully operated.

A problem of the known semi-closed greenhouse is that when the ambient air has a high dew point it becomes difficult to efficiently cool the ambient air. Traditional evaporative cooling does not suffice and more energy consuming refrigerating cooling is required to achieve a sufficient reduction in temperature of the ambient air. An alternative would be to use the so-called closed greenhouse. However a closed greenhouse has the disadvantage that no fresh air is provided to the greenhouse. Thus additional measures to add for example carbon dioxide is required to operate such a greenhouse. Furthermore energy consuming refrigerating cooling is also required for such a closed greenhouse when the ambient temperature is high.

There is thus a desire to provide a process to reduce the temperature of a feed of air in a more efficient manner, especially a feed of air having a high dew point.

The following process achieves this. Process to reduce the temperature of a feed of air by:

(a) contacting the feed of air with liquid water wherein part of the water evaporates to obtain air with a higher humidity and a reduced temperature as compared to the feed of air,

(b) contacting the air obtained in step (a) with an aqueous hygroscopic solution to obtain air with a reduced humidity as compared to the air obtained in step (a) and a water diluted hygroscopic solution,

(c) contacting the air obtained in step (b) with liquid water wherein part of the water evaporates to obtain air with a reduced temperature as compared to the air obtained in step (a),

wherein in a step (d) the water diluted hygroscopic solution obtained in step (b) is concentrated and cooled to obtained a concentrated and cooled hygroscopic solution which solution is used as the aqueous hygroscopic solution or as part of the aqueous hygroscopic solution in step (b).

Applicant found that with the process according to the invention an efficient process is obtained to reduce the temperature of air, especially air having a high dew point. By performing step (b) on a highly saturated air flow obtained in step (a) a water diluted hygroscopic solution having a high energy content is obtained. This energy can be used to further improve the efficiency of the process. Furthermore it is possible to perform this process without having to add fresh water or large amounts of fresh water.

The dew point of the feed of air is preferably high and more preferably above 30 °C. The dew point of the air obtained in step (c) is suitably below 30 °C. Because the saturation of the air obtained in step (c) will be high, suitably above 90% relative humidity, the temperature of the air obtained will be below than 30 °C, suitably between 25 and 29 °C. Such a temperature and saturation of air is suitable for use in a greenhouse.

Step (a) may be performed by any process wherein liquid water directly contacts the feed of air. This may be achieved by spraying water into a stream of feed of air, for example in a transport conduit. Preferably so-called evaporating pads are used where water flows along an open surface area in a downward direction and the feed of air passes the open surface area and water in a substantial horizontal direction. Due to evaporation of part of the liquid water a temperature decrease and a water saturation increase of the air passing the evaporating pad will result. The temperature of the water is preferably between the temperature of the feed of air as provided to step (a) and the dew point of said feed of air. It has been found advantageous that the air obtained in step (a) is saturated with water or almost saturated with water. The air obtained in step (a) preferably has a relative humidity of above 85% and more preferably above 90%.

In step (b) the air obtained in step (a) is contacted with an aqueous hygroscopic solution. This aqueous hygroscopic solution may comprise of hygroscopic salts or glycols. Examples of hygroscopic salts are lithium chloride, magnesium chloride, calcium chloride, potassium formate and sodium chloride. Preferably glycols are used because they are less corrosive. Examples of suitable glycols are ethylene glycol, propylene glycol and butylene glycol. Propylene glycol, also known as 1,2-propanediol, is preferred when the process is used in a greenhouse because this compound is not poisonous.

In step (b) the air obtained in step (a) directly contacts the aqueous hygroscopic solution in a similar manner as in an evaporative cooling pad of step (a). The liquid aqueous hygroscopic solution may run down along an open surface area and the air flows horizontally through said open surface in a so-called hygroscopic dehumidification pad. Water vapor as present in the air is absorbed by the liquid aqueous hygroscopic solution. In this process step water will thus condensate and the resulting latent heat of condensation will result in an increase of temperature of the aqueous hygroscopic solution and an increase in temperature of the air as it contacts the aqueous hygroscopic solution in step (b). In some applications the surface area and liquid water is locally cooled to improve the dehumidification efficiency of the hygroscopic dehumidification pad. Applicants have now found that it is more efficient to obtain a relatively warm water diluted hygroscopic solution in step (b). This because such a warmer water diluted hygroscopic solution in step (b) may be more efficiently regenerated in step (d).

The concentration of 1,2-propanediol in the aqueous hygroscopic solution as provided to step (b) is preferably above 80 wt%. The temperature of the aqueous hygroscopic solution as provided to step (b) is preferably as low as possible, more preferably above -10 °C and even more preferably above 4 °C. The temperature of the aqueous hygroscopic solution as provided to step (b) is preferably below 6 °C above the temperature of the feed of air as provided to step (a) and more preferably below 10 °C.

In step (c) the air obtained in step (b) is contacted with liquid water. This may be performed in the same manner as described for step (a). Preferably step (c) is performed in the earlier described evaporative pad. By performing steps (a) and (b) the dew point and enthalpy of the air is reduced such that when this air is subjected to step (c) an efficient temperature reduction is achieved.

Preferably the air obtained in step (c) is fed to the interior of a greenhouse. In such an application or similar applications where ambient air needs to be supplied to the interior of a building the need to cool the ambient air will vary. For example during day time the dew point and/or temperature of the ambient air may be too high for direct admission into the greenhouse or building, while during the night the dew point and/or temperature may be sufficient for admission. The process is especially suited for such situations because an efficient regeneration of the hygroscopic solution and/or cooling fluids will then be possible as will be explained in more detail below. Suitably the concentration of the water diluted hygroscopic solution of step (d) is thus performed continuously and wherein steps (a), (b) and (c) are performed non-continuously. More preferred is when the concentration of the water diluted hygroscopic solution of step (d) to obtain a concentrated hygroscopic solution is performed at least 23 hours per day and steps (a), (b) and (c) between 1 and 14 hours per day. It will be understood that when steps (a), (b) and (c) are performed the ambient air may have a dew point and/or temperature which requires the temperature reduction process according to the invention to be performed.

In the above continuous-non-continuous process it is preferred that part of the water diluted hygroscopic solution as obtained in step (b) is stored in an insulated storage container and part of the water diluted hygroscopic solution as obtained in step (b) is mixed with the concentrated hygroscopic solution. The resulting mixture is used as the aqueous hygroscopic solution in step (b) in the above referred to 1 to 14 hours per day. The concentrated hygroscopic solution is obtained by evaporation of part of the water as present in a stream of water diluted hygroscopic solution as discharged from the insulated container in at least 23 hours per day. The heat source for performing this evaporation may be any hot gaseous or liquid stream. The heat exchange may be by direct heat exchange and preferably by indirect heat exchange. In such a process embodiment the regeneration of the water diluted hygroscopic solution may be performed in at least 23 hours per day, which in normal continuous operation will be 24 hours per day. In this manner an efficient use is made of the regenerating process equipment.

In the above continuous-non-continuous process it is preferred that the mixture of water diluted hygroscopic solution and concentrated hygroscopic solution is cooled before being used in step (b) when steps (a), (b) and (c) are performed. The mixture is preferably cooled by indirect heat exchange against a cooling fluid resulting in the concentrated and cooled hygroscopic solution and used cooling fluid. This manner of operation results in that the cooling fluid is only used when steps (a), (b) and (c) is performed while the used cooling fluid may be reduced in temperature for reuse as the cooling fluid performed at least 23 hours per day. In this manner an efficient use is made of the process equipment involved in cooling the used cooling fluid.

The used cooling fluid may be reduced in temperature for reuse as the cooling fluid by any known cooling process. Applicant found that an efficient process is achievable when the used cooling fluid is reduced in temperature by means of an absorption refrigerator process. An example of a suitable absorption refrigerator process comprises the steps of (i) evaporation of liquid ammonia, (ii) absorption of ammonia vapour by contacting with liquid water resulting in a water phase saturated with ammonia, (iii) heating the ammonia saturated water phase to separate gaseous ammonia from the liquid water and (iv) cooling the gaseous ammonia such that ammonia condenses for reuse in step (i). In such a process the used cooling fluid is reduced in temperature by the cooling effect of the evaporation of ammonia in step (i). The heat source for performing step (iii) may be any hot liquid or gas stream, for example a waste heat stream. Preferably the heat source is steam. When the steam is also used for the regeneration of the water diluted hygroscopic solution as described above a process is obtained which can be operated using only steam as the source of power. The cooling of gaseous ammonia in step (iv) may be partly performed by indirect heat exchange with the water diluted hygroscopic solution as it is discharged from its storage and before the concentration step. The thus cooled ammonia may be further cooled by conventional means, such as in a cooling tower.

When the air obtained in step (c) is fed to the interior of a greenhouse it may be preferred that the air is fed to the interior of a greenhouse via numerous parallel oriented air distribution tubes having multiple openings along their length such to distribute the air within the interior of the greenhouse. In such a process it may be preferred that the air with a reduced temperature as obtained in step (c) is first supplied to a common space which space is fluidly connected to at least 5 air distribution tubes and to which space a recycle flow of air from within the greenhouse is also provided. More preferably the air with a reduced temperature as obtained in step (c) is first supplied to the common space between the afore mentioned 1 and 14 hours per day and wherein in the remaining time at least a recycle flow of air from within the greenhouse is provided to the common space to be recycled via the tubes back into the greenhouse. In the period that step (a), (b) and (c) are not performed it may still be advantageous to let in ambient air into the greenhouse. For example, the temperature of the ambient air may be sufficiently low during the night that intake of this air can be performed without performing the cooling steps (a)-(c). In that situation it may be preferred to at least partly by-pass the evaporative cooling pads and hygroscopic dehumidification pad. Although no liquid runs through the pads still a pressure drop has to be overcome to draw in the ambient air through the pads. By having a valve between for example the evaporative cooling pad of step (a) and the hygroscopic dehumidification pad of step (b) a by-pass is created with a significantly lower pressure drop.

The invention is also directed to a greenhouse comprising numerous parallel and substantially horizontal oriented air distribution tubes fluidly connected at one side to a common space;

a cooling section comprising of a first evaporative cooling pad, a hygroscopic dehumidification pad and a second evaporative cooling pad, wherein said cooling section fluidly connects the exterior of the greenhouse with the common space;

wherein the common space further comprises one or more openings fluidly connecting the interior of the greenhouse with the common space and means to transport air from the common space into said numerous air distribution tubes. The means to transport air may be by any known air displacement means, such as for example by ventilators positioned at the inlet of each air distribution tube.

The cooling section suitably comprises of an air inlet fluidly connected to the first evaporative cooling pad, an air outlet fluidly connected to the second evaporative cooling pad and a by-pass valve between first cooling pad and hygroscopic dehumidification pad which by-pass valve has a closed position to create a flow path for air through air inlet, the first cooling pad, the hygroscopic dehumidification pad, the second evaporative cooling pad and air outlet to the common space and one or more open positions to enable an alternative flow path for air through the air inlet, first cooling pad and by-pass valve to the common space.

The greenhouse is suitably of the earlier referred to semi-closed type. The greenhouse suitably has a common space defined by a side wall of the greenhouse, a parallel wall spaced from said side wall and a roof, wherein in the side wall the cooling section is provided, wherein in the parallel wall openings are present for fluidly connecting the common space with the air distribution tubes and wherein the parallel wall and/or roof is provided with the one or more openings fluidly connecting the interior of the greenhouse with the common space. The side wall may be the so-called end gable wall or the actual side walls positioned perpendicular to such an end gable wall, given the greenhouse has a rectangular floor plan. The one or more openings fluidly connecting the interior of the greenhouse with the common space are provided with means to open or close these openings such to control the flow of air from within the greenhouse to the common space.

The invention shall be illustrated by the following Figures. Figure 1 is a flow diagram of how the process according to the invention may be performed. The flow diagram will be used to illustrate a possible operating point of the process. Via stream **1** air with a temperature of 36 °C and a saturation of 70% (having a dew point of 30 °C) is contacted with liquid water in first evaporating pad **2.** To first evaporating pad **2** water is supplied from a water tank **3** via stream **4** and returned to tank **3** via stream **5**. From evaporating pad **2** air is obtained in stream **6** having a temperature of 31.9 °C and a saturation of 92%. This air is subsequently contacted with a aqueous hygroscopic solution containing 90 wt% 1,2-propanediol in hygroscopic dehumidification pad **7**. The air in stream **8** as discharged from the hygroscopic dehumidification pad **7** has a temperature of 33.9 °C and a saturation of 67 %. This air is contacted with liquid water in second evaporating pad **9**. The air as obtained in stream **10** has a temperature of 29.5 °C and a saturation of 91 % and with a dew point of 27.9 °C. To second evaporating pad 9 water is supplied from the water tank **3** via stream **11** and returned to tank **3** via stream **12**. To tank **3** fresh water or water obtained elsewhere in the process is added via stream **13**.

From the hygroscopic dehumidification pad **7** a stream **14** of water diluted hygroscopic solution having a temperature of 39 °C is partly send to an insulated storage tank **15** via stream **16** and partly recycled to the hygroscopic dehumidification pad **7** via stream **17**. This part of the water diluted hygroscopic solution as obtained in step (b) is mixed with the concentrated hygroscopic solution as supplied from a storage tank **18** via stream **19**. The mixture is send to the hygroscopic dehumidification pad **7** via stream **20**. Stream **20** is cooled to 6 °C in heat exchanger **21** against a cooling fluid. Cooling fluid is provided to heat exchanger **21** via stream **22** from a cooling fluid storage tank **23**. The used cooling fluid is returned to tank **23** via steam **24**. Stream **24** is reduced in temperature in heat exchanger **25**.

The above described process may be performed discontinuous, or in other words, only during a certain period per day when the conditions of the air in stream **1** require cooling by this process. The concentration of the water diluted hygroscopic solution obtained in step (b) and stored in tank **15** and the cooling of the cooling fluid as present in tank **23** is preferably performed continuously, in other words during the entire 24 hours per day to take full advantage of the process equipment involved.

Concentration of the of the water diluted hygroscopic solution is performed by evaporating part of the water making use of a heat exchanger **26** to which water diluted hygroscopic solution is provided via stream **27**. Because the temperature of the water diluted hygroscopic solution is relatively high because it is stored in an insulated tank less energy is required to evaporate the required amount of water. The heat source used in heat exchanger **26** may be steam as schematically shown as stream **28**. The evaporated water is discharged via stream **29** and may be send to tank **3**.

The cooling fluid as present in tank **23** is continuously reduced in temperature by recirculating the cooling fluid via stream **30** and heat exchanger **25** back to tank **23**. The cooling medium used to cool the cooling fluid in stream **31** is by evaporation of liquid ammonia as part of a absorption refrigerator process **32**. The required heat source of the absorption refrigerator process **32** is steam as provided via stream **33** and discharged via stream **34**.

Figure 2 shows a cross-sectional view AA' of the schematically represented greenhouse of Figure 3. The relative dimensions of the various elements are not scaled and sometimes enlarged or limited in order to improve the clarity of the figures. The greenhouse is provided with an end-wall **40**, also referred to as end gable, a floor **41** and a saddle roof **43** with gutters **42**. Saddle roof **43** is provided with vent openings **44** which can be opened to avoid an over-pressure within the greenhouse. In practice only air flowing to the exterior of the greenhouse will flow through vents **44**. Also a common space **45** is shown which can receive ambient air via cooling section **52** and air from within the greenhouse via opening **51**. Common space **45** is defined by a partition wall **59**, which runs parallel with and spaced away from end wall **40**. Partition wall **59** extends to a position below the gutter **42**. The upper end of the common space is enclosed by a roof **60**. In common space **45** these air streams may be mixed and supplied to the inlet **53** of numerous parallel and substantially horizontal oriented air distribution tubes **46**. The inlet **53** of tubes **46** are provided with a ventilator **55**. Above such tubes **46** the cultivation as grown in the greenhouse may be positioned. The cooling section **52** is provided with an air inlet **50** for entry of ambient air, a first evaporative cooling pad **47**, a hygroscopic dehumidification pad **48** and a second evaporative cooling pad **49**. The supply and discharge conduits for the evaporative fluids and hygroscopic fluids to pads **47**, **48** and **49** as described in Figure 1 are not shown in this

Figure for clarity reasons. The ambient air flows by means of a substantially horizontal flow path through the pads. The treated air will be discharged from the cooling section **52** as indicated by arrow **54**.

Opening **51** can be closed and opened by valve **56** to regulate the amount of air from within the greenhouse. When closed only ambient air will be provided to the greenhouse via tubes **46**. It has been found that some recirculation of greenhouse air is preferred. Thus it may be preferred to design valve **56** such that it cannot fully close opening **51**. Air inlet **50** for ambient air can be closed by vertical door **57**, which can move upwardly along rails **58**. In practice door **57** will not fully enclose air inlet **50** resulting in that some ambient air will always flow to common space **45**.

In Figure 3 the greenhouse according the invention is shown when viewed towards the end wall **40** from the exterior of the greenhouse. The numerals have the same meaning as in Figure 3. Some details, like valves **56**, partition wall **59** and the inlet **53** of tubes **46** are visible because end wall **40** is made of a transparent material. A greenhouse may have a much larger end wall **40** provided with a large air inlet **50** or multiple air inlets **50**.

Figure 4 shows another embodiment for the common space and cooling section. A cooling section **61** is shown provided with the first evaporative cooling pad **47**, the hygroscopic dehumidification pad **48** and the second evaporative cooling pad **49**. Further a louvre **62** is shown which can close the upper part **63** of common space **45** from the lower part **64** of common space **45** as shown in Figure 5. When louvre **62** is open and air inlet **50** is open air from within the greenhouse and ambient air will be drawn into the lower part **64** of common space **45**. In a situation wherein the hygroscopic dehumidification and second evaporative cooling is not required it may be advantageous in such a modus to by-pass these pads by opening a by-pass valve **65** between first cooling pad **47** and hygroscopic dehumidification pad **48**.

Figure 5 shows the common space and cooling section of Figure 4 in a situation wherein louvre **62** are closed and door **57** encloses air inlet **50**. It may be advantageous to cool the greenhouse by passing the relatively humid air from within the greenhouse over the hygroscopic dehumidification pad **48** and second evaporative cooling pad **49**. By opening a second by-pass valve **66** and thereby fluidly connecting the upper space **63** with the inlet of the hygroscopic dehumidification pad **48** such a flow path will result.

CONCLUSIES

1. Werkwijze voor het reduceren van de temperatuur van een aangevoerde luchtstroming, door:

(a) het in contact brengen van de aangevoerde luchtstroming met vloeibaar water, waarbij een deel van het water verdampt om zodoende lucht te verkrijgen met een hogere vochtigheid en met een gereduceerde temperatuur ten opzichte van de oorspronkelijk aangevoerde luchtstroming,

(b) het in contact brengen van de in stap (a) verkregen lucht met een waterige hygroscopische oplossing, teneinde lucht te verkrijgen met een gereduceerde vochtigheid ten opzichte van de in stap (a) verkregen lucht, alsook een in water verdunde hygroscopische oplossing,

(c) het in contact brengen van de in stap (b) verkregen lucht met vloeibaar water, waarbij een deel van het water verdampt om zodoende lucht te verkrijgen met een gereduceerde temperatuur ten opzichte van de lucht die verkregen werd in stap (a),

waarbij in een stap (d) de in water verdunde hygroscopische oplossing zoals die verkregen werd in stap (b), wordt geconcentreerd en afgekoeld, teneinde een geconcentreerde en afgekoelde hygroscopische oplossing te verkrijgen, waarbij deze oplossing wordt gebruikt als de waterige hygroscopische oplossing of als deel van de waterige hygroscopische oplossing in stap (b).

2. Werkwijze volgens conclusie 1, waarbij het dauwpunt van de aangevoerde luchtstroming hoger ligt dan 30 °C.

3. Werkwijze volgens conclusie 1 of conclusie 2, waarbij de waterige hygroscopische oplossing 1,2-propaandiol omvat.

4. Werkwijze volgens een der conclusies 1 tot en met 3, waarbij het dauwpunt van de in stap (c) verkregen lucht lager ligt dan 30 °C.

5. Werkwijze volgens een der conclusies 1 tot en met 4, waarbij de concentratie van de in water verdunde hygroscopische oplossing uit stap (d) continu wordt uitgevoerd, en waarbij de stappen (a), (b), en (c) niet-continu worden uitgevoerd.

6. Werkwijze volgens conclusie 5, waarbij de concentratie van de in water verdunde hygroscopische oplossing uit stap (d), met als doel het verkrijgen van een geconcentreerde hygroscopische oplossing, ten minste 23 uren per dag wordt uitgevoerd, en de stappen (a), (b), en (c) gedurende 1 tot 14 uren per dag worden uitgevoerd.

7. Werkwijze volgens conclusie 6, waarbij een deel van de in water verdunde hygroscopische oplossing zoals die verkregen wordt in stap (b), wordt opgeslagen in een geïsoleerde opslagcontainer, en een deel van de in water verdunde hygroscopische oplossing zoals die verkregen wordt in stap (b), wordt gemengd met de geconcentreerde hygroscopische oplossing, waarbij het resulterende mengsel wordt gebruikt als de waterige hygroscopische oplossing in stap (b) gedurende de 1 tot 14 uren per dag, en waarbij de geconcentreerde hygroscopische oplossing wordt verkregen door middel van een verdamping van een deel van het water dat aanwezig is in een stroom van in water verdunde hygroscopische oplossing zoals die wordt afgegeven vanuit de geïsoleerde containers gedurende de ten minste 23 uren per dag.

8. Werkwijze volgens conclusie 7, waarbij het mengsel wordt afgekoeld alvorens gebruikt te worden in stap (b) wanneer de stappen (a), (b), en (c) worden uitgevoerd.

9. Werkwijze volgens conclusie 8, waarbij de geconcentreerde hygroscopische oplossing wordt afgekoeld door middel van een onrechtstreekse warmte-uitwisseling met een koelfluïdum, met als resultaat de geconcentreerde en afgekoelde hygroscopische oplossing en gebruikt koelfluïdum.

10. Werkwijze volgens conclusie 9, waarbij de temperatuur van het gebruikte koelfluïdum wordt gereduceerd met het oog op het hergebruik ervan als koelfluïdum in een koelstap die ten minste 23 uren per dag wordt uitgevoerd.

11. Werkwijze volgens conclusie 10, waarbij de temperatuur van het koelfluïdum wordt gereduceerd door middel van een absorptie-koelwerkwijze.

12. Werkwijze volgens conclusie 11, waarbij de absorptie-koelwerkwijze de stappen omvat met (i) het verdampen van vloeibaar ammoniak, (ii) het absorberen van ammoniakdamp door het in contact brengen met vloeibaar water, met als resultaat een waterige fase die verzadigd is met ammoniak, (iii) het verhitten van de met ammoniak verzadigde waterige fase, teneinde gasvormig ammoniak af te scheiden van het vloeibare water, en (iv) het afkoelen van het gasvormige ammoniak, op een zodanige wijze dat het ammoniak condenseert en hergebruikt kan worden in stap (i).

13. Werkwijze volgens conclusie 12, waarbij de temperatuur van het koelfluïdum gereduceerd wordt door het afkoelende effect van de verdamping van ammoniak in stap (i).

14. Werkwijze volgens een der conclusies 1 tot en met 13, waarbij de lucht met een gereduceerde temperatuur ten opzichte van de aangevoerde luchtstroming, zoals die verkregen wordt in stap (c), wordt aangevoerd naar het inwendige van een kas.

15. Werkwijze volgens conclusie 14, waarbij de lucht wordt aangevoerd naar het inwendige van een kas via diverse parallel georiënteerde luchtverdelingsbuizen die langs hun lengte voorzien zijn van meerdere openingen, zodat de lucht verdeeld wordt in het inwendige van de kas.

16. Werkwijze volgens conclusie 14, waarbij de lucht met een gereduceerde temperatuur, zoals die verkregen wordt in stap (c), eerst wordt aangevoerd naar een gemeenschappelijke ruimte, waarbij deze ruimte in fluïdumverbinding staat met ten minste 5 luchtverdelingsbuizen, en waarbij naar deze ruimte eveneens een vanuit het inwendige van de kas gerecycleerde luchtstroming wordt aangevoerd.

17. Werkwijze volgens conclusie 16, waarbij de lucht met een gereduceerde temperatuur, zoals die verkregen wordt in stap (c), eerst wordt aangevoerd naar de gemeenschappelijke ruimte, en dit gedurende 1 tot 14 uren per dag, en waarbij gedurende de rest van de tijd ten minste een vanuit het inwendige van de kas gerecycleerde luchtstroming naar de gemeenschappelijke ruimte wordt aangevoerd om vervolgens via de buizen terug in de kas gerecycleerd te worden.

18. Kas, omvattende

diverse parallelle en in hoofdzaak horizontaal georiënteerde luchtverdelingsbuizen die langs één zijde in fluïdumverbinding staan met een gemeenschappelijke ruimte;

een koelsectie die ten minste een eerste verdampend koelkussen omvat, een hygroscopisch ontvochtigingskussen, en een tweede verdampend koelkussen, waarbij de koelsectie een fluïdumverbinding vormt tussen het uitwendige van de kas en de gemeenschappelijke ruimte;

waarbij de gemeenschappelijke ruimte bovendien een of meerdere openingen omvat die een fluïdumverbinding vormen tussen het inwendige van de kas en de gemeenschappelijke ruimte, alsook middelen omvat om lucht vanuit de gemeenschappelijke ruimte over te brengen naar de diverse luchtverdelingsbuizen.

19. Kas volgens conclusie 18, waarbij de koelsectie een luchtinlaat omvat die in fluïdumverbinding staat met het eerste verdampende koelkussen, een luchtuitlaat die in fluïdumverbinding staat met het tweede verdampende koelkussen, en een bypassklep tussen het eerste koelkussen en het hygroscopische koelkussen, waarbij de bypassklep een gesloten positie omvat om een stromingstraject te creëren voor lucht doorheen de luchtinlaat, het eerste koelkussen, het hygroscopische ontvochtigingskussen, het tweede verdampende koelkussen, en de luchtuitlaat naar de gemeenschappelijke ruimte, alsook een of meerdere open posities om een alternatief stromingstraject mogelijk te maken voor lucht doorheen de luchtinlaat, het eerste koelkussen, en de bypassklep naar de gemeenschappelijke ruimte.

20. Kas volgens conclusie 18 of conclusie 19, waarbij de gemeenschappelijke ruimte wordt gedefinieerd door een zijwand van de kas, door een parallelle wand op een afstand

van de zijwand, en door een dak, waarbij in de zijwand de koelsectie is voorzien, waarbij in de parallelle wand openingen aanwezig zijn om een fluïdumverbinding te vormen tussen de gemeenschappelijke ruimte en de luchtverdelingsbuizen, en waarbij de parallelle wand en/of het dak zijn of is voorzien van de ene of meerdere openingen die een fluïdumverbinding vormt of vormen tussen het inwendige van de kas en de gemeenschappelijke ruimte.

21. Kas volgens conclusie 20, waarbij de een of meerdere openingen die een fluïdumverbinding vormen tussen het inwendige van de kas en de gemeenschappelijke ruimte, zijn voorzien van middelen om deze openingen te openen of te sluiten om zodoende de luchtstroming vanuit het inwendige van de kas naar de gemeenschappelijke ruimte te controleren.

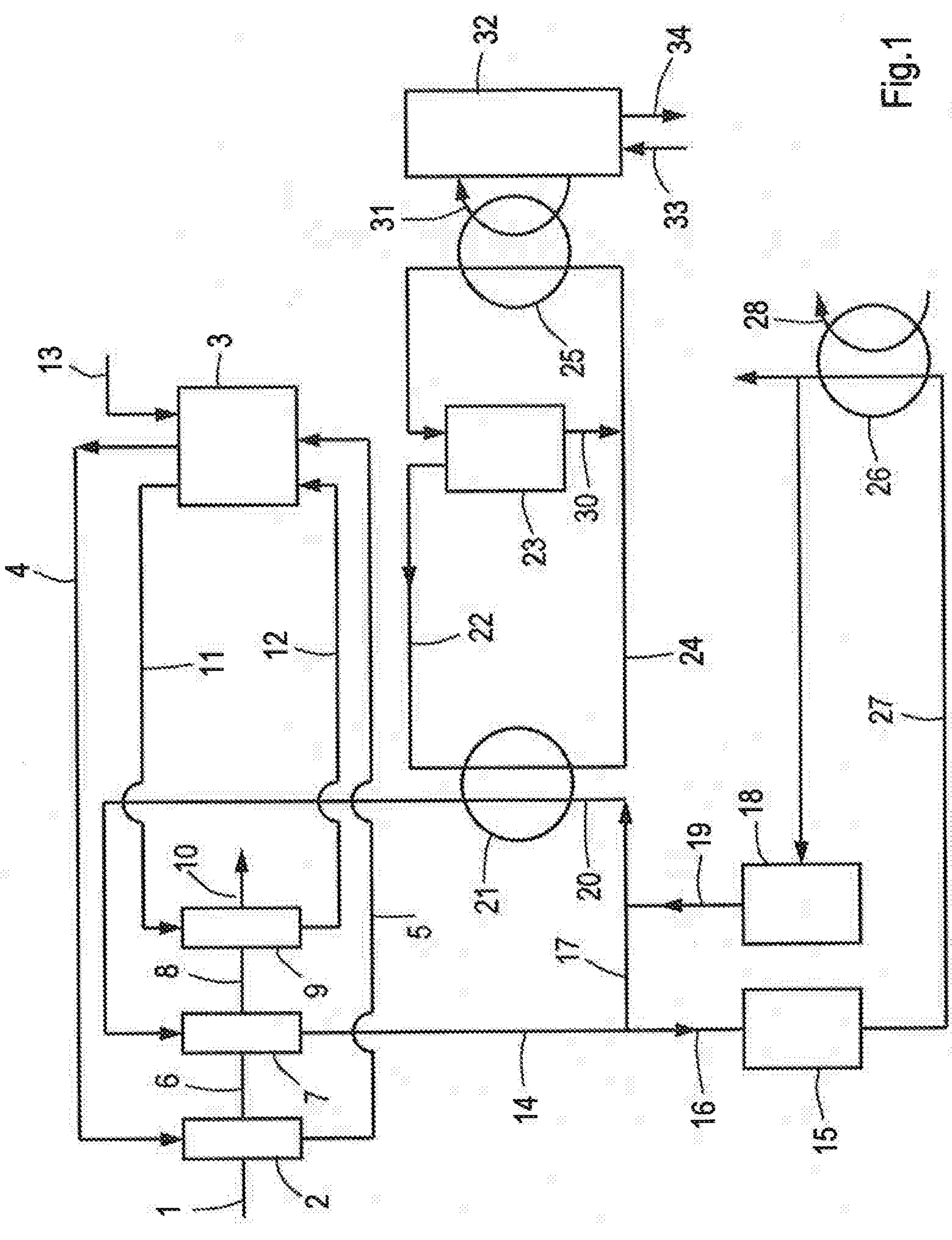

Fig.1

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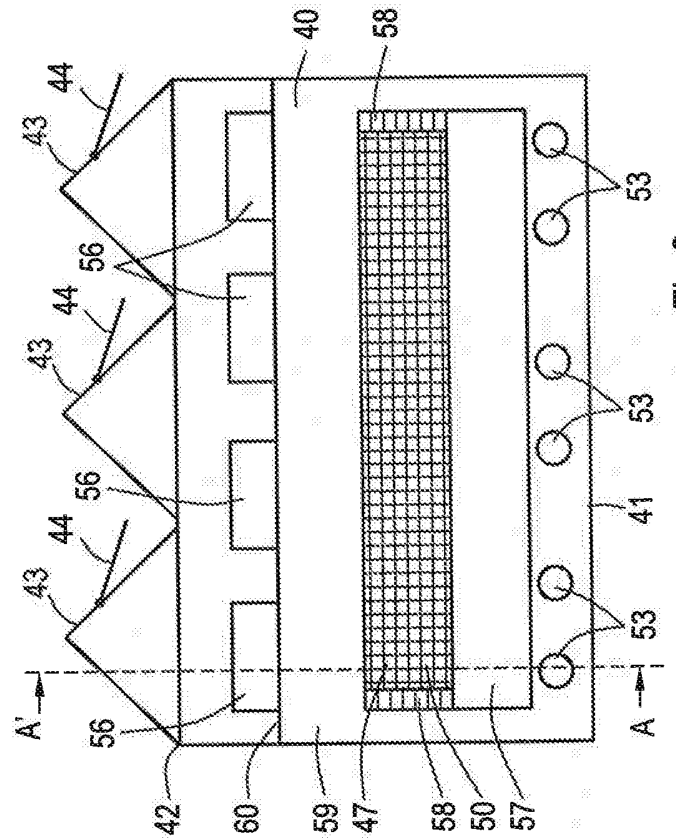
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Fig.3

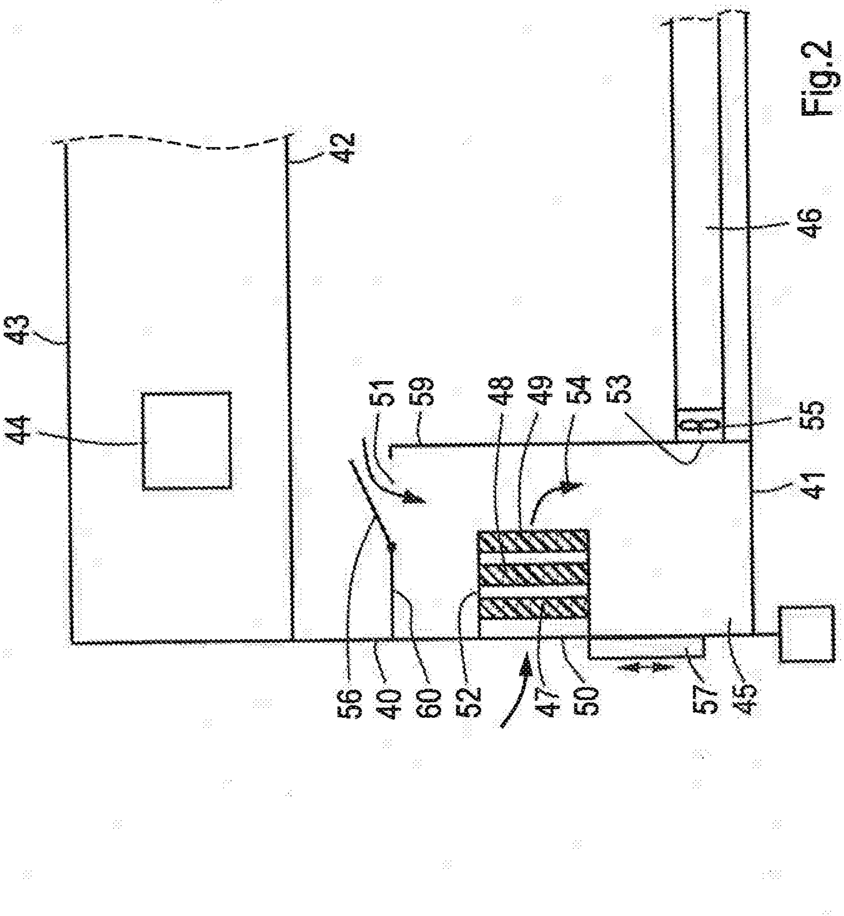
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Fig.2

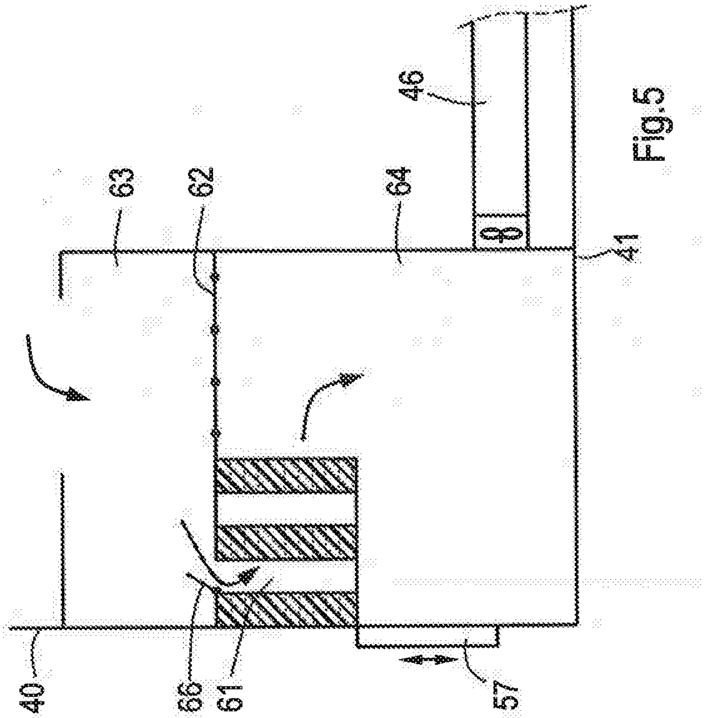
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Fig.5

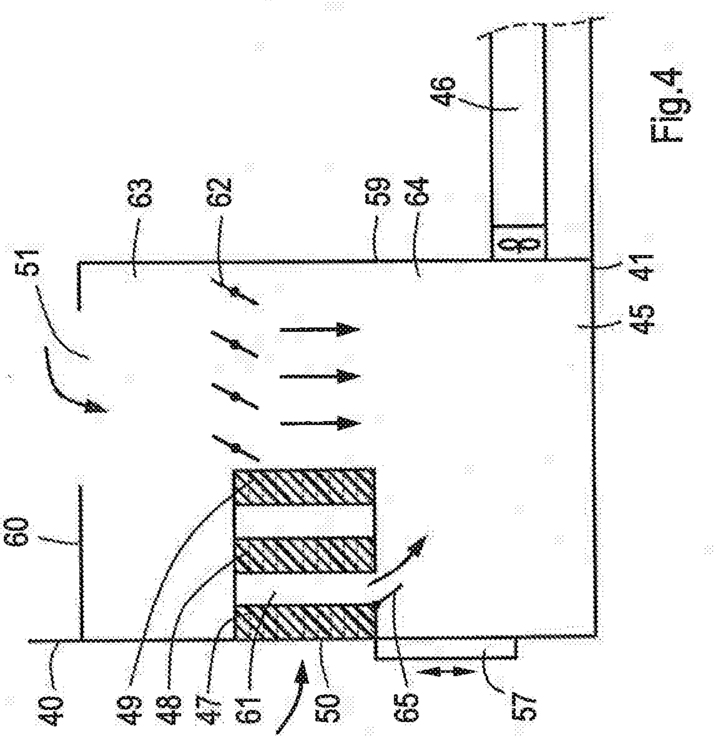
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Fig.4

ABSTRACT

Process to reduce the temperature of a feed of air by (a) contacting the feed of air with liquid water wherein part of the water evaporates to obtain air with a higher humidity and a reduced temperature. The air obtained in step (a) is contacted in step (b) with an aqueous hygroscopic solution to obtain air with a reduced humidity. In a step (c) the air obtained in step (b) is contacted with liquid water wherein part of the water evaporates to obtain air with a reduced temperature as compared to the air obtained in step (a). In a step (d) the water diluted hygroscopic solution obtained in step (b) is concentrated and cooled to obtained a concentrated and cooled hygroscopic solution which solution is used as the aqueous hygroscopic solution or as part of the aqueous hygroscopic solution in step (b).

[Figure 1]

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE **2016.010 NL/PD**
Nederlands aanvraag nr. **2016574**	Indieningsdatum **08-04-2016**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **J.M. van der Hoeven B.V.**	
Datum van het verzoek voor een onderzoek van internationaal type **11-06-2016**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN66579**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

F24F5/00;F24F3/14;A01G9/24

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC	**F24F;A01G**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III.	☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV.	☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2016574

A. CLASSIFICATIE VAN HET ONDERWERP
INV. F24F5/00 F24F3/14 A01G9/24
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte miminum documentatie (classificatie gevolgd door classificatiesymbolen)
F24F A01G

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)

EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	US 4 171 620 A (TURNER NELSON C [US]) 23 oktober 1979 (1979-10-23) * het gehele document * -----	1-21
A	US 2015/047382 A1 (JAPPEN OWEN P [US] ET AL) 19 februari 2015 (2015-02-19) * alinea [0004] * * alinea [0027] - alinea [0038] * * figuren * -----	1,18
A,D	WO 2004/032606 A1 (ECONCERN B V [NL]; SCHOONDERBEEK GILBERTUS GUALTH [NL]; OPDAM JOANNES) 22 april 2004 (2004-04-22) in de aanvraag genoemd * samenvatting; figuren * -----	1
	-/--	

[X] Verdere documenten worden vermeld in het vervolg van vak C.

[X] Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid

24 november 2016

Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type

Naam en adres van de instantie

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

1

De bevoegde ambtenaar

Mattias Grenbäck

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2016574

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A,D	EP 1 464 219 A1 (FORSCHUNGSZENTRUM JUELICH GMBH [DE]) 6 oktober 2004 (2004-10-06) in de aanvraag genoemd * samenvatting; figuren * -----	1
A,D	WO 2008/002686 A2 (HOUWELING NURSERIES OXNARD INC [US]; HOUWELING CASEY [CA]; CUMMINGS PE) 3 januari 2008 (2008-01-03) in de aanvraag genoemd * figuur 1 * -----	1

1

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek

NL 2016574

In het rapport genoemd octrooigeschrift		Datum van publicatie	Overeenkomend(e) geschrift(en)		Datum van publicatie
US 4171620	A	23-10-1979	GEEN		
US 2015047382	A1	19-02-2015	GEEN		
WO 2004032606	A1	22-04-2004	AU 2003274818	A1	04-05-2004
			DE 60317698	T2	17-07-2008
			DK 1553816	T3	11-08-2008
			EP 1553816	A1	20-07-2005
			ES 2297213	T3	01-05-2008
			NL 1023434	C2	14-04-2004
			WO 2004032606	A1	22-04-2004
EP 1464219	A1	06-10-2004	DE 10315626	A1	04-11-2004
			EP 1464219	A1	06-10-2004
WO 2008002686	A2	03-01-2008	DK 2031957	T3	13-01-2014
			EP 2031957	A2	11-03-2009
			EP 2698057	A2	19-02-2014
			ES 2436111	T3	27-12-2013
			IL 193844	A	29-08-2013
			PT 2031957	E	09-12-2013
			SI 2031957	T1	31-12-2013
			US 2008000151	A1	03-01-2008
			US 2014150336	A1	05-06-2014
			WO 2008002686	A2	03-01-2008

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN66579	08.04.2016		NL2016574

International Patent Classification (IPC)
INV. F24F5/00 F24F3/14 A01G9/24

Applicant
J.M. van der Hoeven B.V.

This opinion contains indications relating to the following items:

- ☒ Box No. I — Basis of the opinion
- ☐ Box No. II — Priority
- ☐ Box No. III — Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV — Lack of unity of invention
- ☒ Box No. V — Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI — Certain documents cited
- ☐ Box No. VII — Certain defects in the application
- ☐ Box No. VIII — Certain observations on the application

Examiner
Mattias Grenbäck

WRITTEN OPINION

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	1-21
	No:	Claims	
Inventive step	Yes:	Claims	1-21
	No:	Claims	
Industrial applicability	Yes:	Claims	1-21
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

D1 US 4 171 620 A (TURNER NELSON C [US]) 23 oktober 1979 (1979-10-23)

D2 US 2015/047382 A1 (JAPPEN OWEN P [US] ET AL) 19 februari 2015 (2015-02-19)

D3 WO 2004/032606 A1 (ECONCERN B V [NL]; SCHOONDERBEEK GILBERTUS GUALTH [NL]; OPDAM JOANNES) 22 april 2004 (2004-04-22)in de aanvraag genoemd

D4 EP 1 464 219 A1 (FORSCHUNGSZENTRUM JUELICH GMBH [DE]) 6 oktober 2004 (2004-10-06)in de aanvraag genoemd

D5 WO 2008/002686 A2 (HOUWELING NURSERIES OXNARD INC [US]; HOUWELING CASEY [CA]; CUMMINGS PE) 3 januari 2008 (2008-01-03)in de aanvraag genoemd

1 Document D1 is regarded as being the prior art closest to the subject-matter of claim 1, and discloses a process to reduce the temperature of a feed of air by steps (b) and (c) of appending claim 1

1.1 The subject-matter of claim 1 therefore differs from this known process in that steps (a) and (d) are not disclosed by document D11, nor is the order of steps (a) to (d) disclosed and the subject matter of claim 1 is therefore new.

1.2 The problem to be solved by the present invention may be regarded as reducing the temperature of feed air in a more efficient manner.

1.3 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step for the following reasons : The features of independent claim 1 is neither known nor is it rendered obvious by the available prior art.

1.4 The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding independent claim 18, which therefore is also considered new and inventive.

2 Claims 2-17 and 19-21 are dependent on claims 1 and 18 and as such also meet the requirements of novelty and inventive step.