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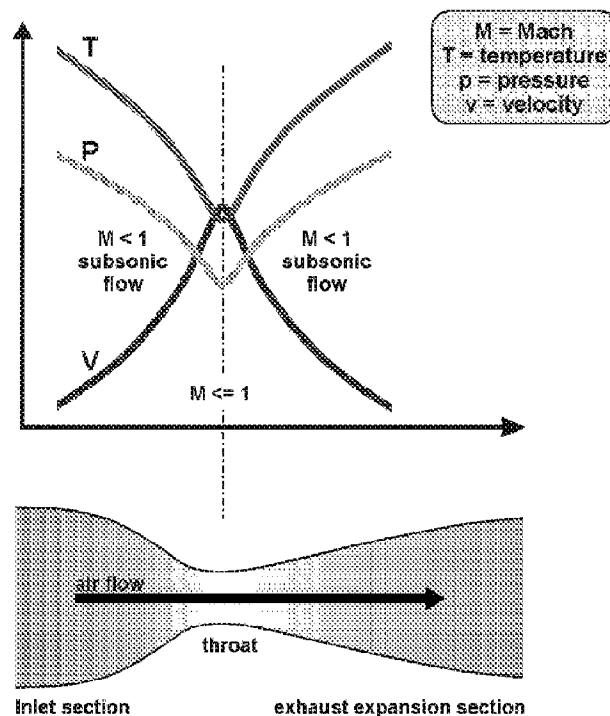
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(71) Demandeur/Applicant:  
BOS, ARIE CORNELIS, NL  
(72) Inventeurs/Inventors:  
WIND, JAAP, NL;  
BOS, ARIE CORNELIS, NL  
(74) Agent: MOFFAT & CO.

(54) Titre : SYSTEME ET PROCEDE DE DESHYDRATATION ET DE DESINFECTION SUPERSONIQUE  
(54) Title: SUPERSONIC DEHYDRATION AND DISINFECTION SYSTEM AND METHOD

**FIGURE 1A**



(57) **Abrégé/Abstract:**

Methods and apparatus are provided, which allow for the partial or full dehydration of organic or inorganic matter containing water by induction of this matter into a vacuum and processing this matter through a specially designed acceleration channel. The induced matter accelerates in air from zero speed to sub-sonic speed to reach supersonic speed. As the material transitions the sound barrier it is subject to acoustic shock waves and an instant negative pressure drop occurs. The sound waves disintegrate, disinfect the material and extract part or all moisture from any organic or inorganic material.



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**Abstract:**

Methods and apparatus are provided, which allow for the partial or full dehydration of organic or inorganic matter containing water by induction of this matter into a vacuum and processing this matter through a specially designed acceleration channel. The inducted matter accelerates in air from zero speed to sub-sonic speed to reach supersonic speed. As the material transitions the sound barrier it is subject to acoustic shock waves and an instant negative pressure drop occurs. The sound waves disintegrate, disinfect the material and extract part or all moisture from any organic or inorganic material.

**SUPERSONIC DEHYDRATION AND DISINFECTION SYSTEM AND METHOD****FIELD OF THE DISCLOSURE**

[0001] The present disclosure relates generally to systems and methods for drying and disinfecting organic materials.

**5 BACKGROUND**

[0002] **Drying organic materials**

[0003] In agriculture, crops and plants are harvested after they have fully grown and produced crop or produce. For most agricultural products, except for greenhouse operations, harvesting is bound to certain seasons throughout the year. The harvested  
10 product always contains water. Some products, like tomatoes, consist of a large percentage of water, while others, like corn, contain much less.

[0004] All products require transportation from the farm. Transportation and storage represent a significant additional cost factor for growers, distributors and, indirectly, for consumers. These costs may be substantially reduced by drying certain produce before  
15 transportation. Crop drying also extends the useable shelf life and/or storage life of the produce.

[0005] A substantial percentage of all agricultural products is used in bulk the food industry instead of being directly consumed. Sometimes lesser quality products are selected for this purpose, and packaging and transportation of bulk products requires less  
20 care than products intended for direct consumer sales.

[0006] With certain products, e.g. tomatoes, trucks can be fully loaded to transport the tomatoes to a tomato-processing company where the produce is used as an ingredient in other food products such as pizza, soup, or ketchup. Tomatoes contain 80% water and bell peppers contain 80% air. Transporting such produce is inefficient as mostly water or air is  
25 being transported. At the processing site the uncut, wet product requires considerable storage space before it can be processed. Special conditions such as refrigeration and related costs to avoid decomposition and molding (mildew) of the product at the processing site may be required before the material can be processed.

[0007] Other products, like hemp, hops, or grains, cannot be processed directly. They  
30 first need to dry. Sometimes this happens on the land with all related risks of weather, insect, bird or vermin damage, mold, mildew, and rot in the product. For example, hemp tops, grown for the production of medicinal CBD oils, must be dried within 48 hours after harvesting to prevent mold.

[0008] Furthermore, the longer harvested produce waits before being dried and  
35 processed, the more its quality deteriorates.

[0009] In other situations, the produce is transported in wet and fresh condition and is dried using industrial processes. For example, hops to produce beer, or hemp buds to produce CBD oils. In order to dehydrate large quantities of hops, breweries have their own hop-driers. These are large machines and batch operated. The machines dry hops using

high temperatures, fossil fuels and require several hours to dry the hops. This intensive process is not suitable for every product. For example, for hemp this process is not optimal. The high temperature and possible fumes can damage or destroy the medicinal CBD oil, which is extracted from the buds.

- 5 [0010] Many agricultural products that need drying, lose a substantial part of the nutrients or the food quality (vitamins, fiber strength) due to the high temperature to which they are exposed during the drying process.

- 10 [0011] Most agricultural products grown on vines, bushes or in orchards trees leave a considerable waste biomass after harvest of the grape, berries, or fruit. The waste biomass includes trimmings, stalks, leaves and root mass. This material then needs to be removed and is treated as agricultural waste. It must either be transported to an approved incineration facility or landfill or left in the open field to naturally decompose. It cannot be re-used immediately or sold as bio-organic fertilizer.

- 15 [0012] This plant waste can become a very heavy and voluminous mass. For example, from large greenhouses. For example, for tomato crops. Many have several hundred acres under glass. The seasonal waste is not edible by livestock and has no purpose, except being used as biofuel after it has been dried. The waste material can no longer be burned in the open air due to pollution controls. It is transported to specialized incineration facilities. It is expensive to transport raw, wet, bulky waste biomass. A solution is "on site" drying to  
20 reduce weight, volume, and transportation costs.

- 25 [0013] Most processes for drying organic material use fossil fuel to heat up material to be dried. The material is spread out over wide and long (roller) beds, and is transported slowly over a heated area, during which time the material dehydrates. These installations are normally large and capital intensive and consume a large amount of energy. Because  
of the long time the organic material is exposed to high temperatures, the quality of ingredients may be compromised.

[0014] Other drying installations will only dry extremely wet (>90% moisture) materials like hog-manure using centrifuges. The maximum reduction of moisture in this method is approximately 50%.

- 30 [0015] **Treating Waste**

- 35 [0016] In some countries, manure from livestock and litter from poultry farms is a large problem. Chicken litter contains high concentrations of nitrates or ammonia. In many countries, it is not allowed to use this manure as fertilizer as it will gradually destroy the capacity of soils to grow new crops. Specialized companies empty the wet manure pits and/or transport the chicken litter. Animal manure, for example pig manure, can contain more than 90% water. This is converted on-site into biogas. This requires substantial investment in storage tanks and many biogas facilities are closing because natural gas is less expensive. Alternately, the liquid manure is transported to locations where it is dried, separated, and processed. This is a very costly obligation for the farmers and imposes a  
40 heavy regulatory burden on farmers, processing companies and regulators.

[0017] Worldwide, household waste is a mixed combination of non-organic (mainly paper, glass, and plastics), and organic (food waste) materials. The organic materials contain high levels of moisture. Drying and compacting these waste products prior to disposal in landfill, or being able to recycle them, is an ongoing environmental priority.

5 [0018] Slaughterhouse waste can consist of many animal parts that are not used in the production of food. Examples are chicken hearts and liver, bones, blood and non-edible organs from cattle and pigs. These, and other parts, go to specialized companies who can extract the proteins of all this waste material for the purpose of food supplements, pet-food, and other products. A large proportion of these waste animal parts, in terms of both  
10 weight and volume, is comprised of water that is not useful to the companies that take these waste parts. Transportation of the waste animal parts in their original form, including the water, is therefore inefficient.

[0019] In some agricultural industries, large volumes of water are needed as irrigation water to produce crops (e.g. tomatoes). The roots, stems, stalks, and leaves are long, heavy  
15 and contain up to 85% water. The plant can reach a length of 14-15 meters. The waste plants are cut and disposed of. For large tomato producers, this means millions of liters of water are lost after each growth cycle. If these waste plants are shredded and dried, the water may be extracted and fed back into the irrigation system of a greenhouse. Weight and volume of the dried biomass is also reduced. This, in turn, reduces disposal handling  
20 and transportation costs.

[0020] In some food industries, large amounts of partially prepared foods are ultimately not used and can become difficult to remove, process and store. As an example, large industrial bakeries have fixed daily supply contracts with large retail client including supermarket chains. The chain grocery stores process their daily sales results for the day  
25 and adjust purchases of incoming products for the next morning. This can mean that a bakery, having a fixed order contract, for example, for 300,000 loaves of bread a day, is notified at 9 p.m. that 50,000 of them are canceled. However, the dough is already prepared and must be destroyed. That material is very sticky, and a large portion of it is comprised of water. The costs of getting the material out of the machine and packing and  
30 storing it as waste material are high. A large part of this cost is due to the high proportion of water, both in terms of volume and weight, contained in the waste product. This water makes the product much heavier and more cumbersome to handle.

[0021] With growing environmental awareness and responsibility, large waste processing companies have been established in the last 10 years. One area of their  
35 activities is the processing of household organic waste (fruit, vegetables, garden, called GFT). In many countries GFT must be disposed of separately from plastic, glass paper and other materials. GFT is processed in bio-digestors, and exits as a heavy, smelly sludge. It still contains approximately 55% water. It then is dried in large fossil-fuel based drying installations using expensive natural gas or propane. It is then mixed with peat and sold in  
40 garden centers as fertilizer.

[0022] Companies exists in Europe to process used infant and adult diapers. These consist of a combination of high-quality plastics and man-made absorbent material. After use, they are disposed of separately by consumers, for example, in the Netherlands,

Germany and Belgium. The absorbent fibers cannot be separated from the plastic. The diapers are rinsed and then dried, melted, shredded, and recycled into low-grade products, such as road signs. If the absorbent material can be dried and separated from the plastic, the plastic could then be used to produce higher value recycled products.

5 [0023] In general household waste, plastic bags and packaging are a major problem to separate and process as waste. Because all waste contains fluids and fats (example: yoghurt, butter, oils, left over drinks, rotting fruits and vegetables and many more), it is very hard to recycle the plastic elements in it. If this wet waste could be easily dried, it would be possible to separate the plastics from the organic materials, and the plastics could  
10 be recycled.

[0024] Worldwide, civil maintenance service companies clean out sewage systems of "human manure". This matter contains only a small percentage of solid materials, the remainder is moisture. To be permitted to transport "human manure" in accordance with regulations in Europe (and elsewhere), it must be dry and free of bacteria. There are  
15 relatively easy ways to reduce the moisture level to 30%, but further reduction is difficult and expensive. There appear to be no known inexpensive or efficient ways to dry the manure matter on site such that transport is allowed. If the material would be completely dry, free of bacteria and smell, transportation and disposal would be simpler, and less expensive.

20 [0025] **Pulverizing materials**

[0026] Zeolite is abundantly available worldwide. It is a light, soft rock. It is used as a soil conditioner on agriculture, in animal feedstocks and in water treatment. In certain deposits of zeolite flakes of gold can be found. To separate the gold traces from the zeolite is difficult. Grinding and applications of toxic chemicals is required. Drying and pulverizing  
25 the zeolite would facilitate gold extraction.

[0027] Another recently discovered application for zeolite is its fire-extinguishing capacity when used in powdered form. This powder could replace water, dispatched from firefighting aircraft. It weighs much less than water and has equal or better extinguishing capabilities. Zeolite is also beneficial to soils. It can replace environmentally harmful fire  
30 suppressants currently in use.

[0028] Some volcanic rock contains extraordinary combinations of minerals. It is known that these minerals, once extracted and dissolved in water, can have positive impact on the health of human beings and animals, and can increase crop yields. Currently, to convert massive 1-ton pieces of volcanic rock into a powder from which minerals can be  
35 dissolved into water, takes 9 steps, of which the last 5 steps are the most expensive. These last 5 steps bring the material from approx. ¾ of an inch to fine powder, which is required before minerals can be extracted and dissolved in water.

[0029] In the food industry, nuts are used in many products. Nuts are mainly used in pressed (oil) or pulverized form as an ingredient for food products. the process to dry and  
40 pulverize the nuts is costly and time consuming.

[0030] All the foregoing examples illustrate scenarios in which the ability to dry moisture-bearing material, or to pulverize organic and non-organic materials, would be highly beneficial. Many existing technologies and equipment for drying use thermal processes (essentially hot air ovens) and fossil fuels to slowly dehydrate the target products. In certain situations, and with certain materials (for example, hemp-buds), the time that this process takes, and the temperature used to dry the material adversely impact the quality of the final product.

[0031] **Disinfection and eradication**

[0032] In other situations, bacteria must be eradicated from manure, sludge, waste materials and infected crops. This is a difficult process and is based mainly upon the use of fossil fuels to eradicate bacteria, fungi, spores, and mildew.

[0033] Also, the human manure referred to above may be used as crop fertilizer, but only if it is free of bacteria. Currently, there are no known ways to guarantee that such manure is bacteria free. If this could be done, human manure could be used as fertilizer.

[0034] In other situations, airborne bacteria or viruses need to be eradicated from airstreams. For example, in buildings like airports, factories, hospitals, educational facilities, government buildings, theaters, convention centers, hotels, casinos and large greenhouse complexes, large volumes of air need to be cleaned and disinfected, or kept as bacteria- and virus-free as possible. There are several methods to eradicate air-borne pathogens. Some of these technologies work instantly but with low volume or capacity, others work with a high capacity but work slowly and on a continuous basis. However, there is a global need for exceptionally large volumes of air to be disinfected both constantly and instantaneously.

[0035] **Combinations of the above**

[0036] Severe virus outbreaks, whether local or global, cause tremendous problems in many sectors of society and industry. In particular, the animal industry and the food industry face enormous problems with the growth and the slaughtering of animals. In some cases, whole animal farms must be closed, and all animals are destroyed in the event infections are found, even when only a single animal is detected as the carrier of a disease. There is no good way to dispose of these animals except preventive clearance by euthanasia and incinerating or burying the animals. They cannot go to a slaughterhouse.

[0037] In similar situations, slaughterhouses themselves can be a source of infection and its spread. Continuously cold working environments may be bad for bacteria but are actually good for viruses. When slaughterhouses are closed, as in current times, even temporarily, thousands of animals remain at farms where they must be fed or euthanized.

[0038] World-wide, large amounts of meat is currently produced but not used. Special facilities exist where this meat is being destroyed. This is to prevent bacterial spread when the meat decomposes. Caution in handling the material is of great importance. When meat rots, maggots and other protein-rich lifeforms transition themselves from leftover meat into new form of life. All these materials, whether alive or dead, are extremely protein rich,

and could be a perfect base for animal food provided it is quickly processed and efficiently and made bacteria-free.

5 [0039] In similar situations, there is a need for animals to get mineral and protein rich food, combined with the right fibers to stimulate healthy digestion. When animals are fed nutritious food, the risk of developing infections, and therefore becoming a cost item to the farmer instead of a profit item, is greatly reduced. This situation can be achieved by mixing proteins, fibers, and carbohydrates in the right way, and in the right composition. If such nutritious food can be produced in a cost-effective manner, the need and cost for medicines, antibiotics, additional nutrients, and vitamins for animals can be substantially reduced.

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### SUMMARY OF THE INVENTION

[0040] The present disclosure provides an apparatus for dehydrating or disinfecting material, comprising: an acceleration channel having an inlet for receiving an air stream and material to be dehydrated, an outlet for discharging said air stream and dehydrated, disinfecting material, and a constriction positioned between the inlet and the outlet; an air mover in communication with the acceleration channel for moving an air stream and material to be dehydrated through the acceleration channel such that the velocity of the air stream and material moving through the constriction is equal to or greater than the speed of sound; and a cyclone in communication with the outlet of the acceleration channel for receiving said discharged air stream and dehydrated, disinfecting material, and separating said dehydrated, disinfecting material from said air stream.

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[0041] In some embodiments, the constriction is positioned at least 400 millimeters from the inlet of the acceleration channel.

25 [0042] In some embodiments, the constriction comprises: an inclination section, along the length of which the diameter of the acceleration channel decreases; a widening section, along the length of which the diameter of the acceleration channel increases; and a throat, located at a point between the inclination section and the widening section where the diameter of the acceleration channel is smallest.

30 [0043] In some embodiments, the length of the inclination section is within the range of 100 millimeters and 400 millimeters.

[0044] In some embodiments, the length of the widening section is within the range of 60 millimeters and 120 millimeters.

35 [0045] In some embodiments, the ratio of the diameter of the acceleration channel at the throat, to the maximum diameter of the acceleration channel is within the range of 1:2.5 to 1:10.

[0046] In some embodiments, the acceleration channel has an interior diameter of about 160 millimeters at all points outside the constriction.

[0047] In some embodiments, an intake of the air mover is in communication with the outlet of the acceleration channel, and the cyclone is in communication with an outlet of the air mover.

5 [0048] In some embodiments, the air mover is a turbine capable of generating under pressure in the range of -290 millibar to -390 millibar, and airflow capacity in the range of 1.5 m<sup>3</sup> per second to 1.66 m<sup>3</sup> per second.

[0049] In some embodiments, the apparatus further comprises an air pressure sensor in communication with the acceleration channel, for measuring air pressure within the channel.

10 [0050] The present disclosure also provides a method of dehydrating, the method comprising the steps of: directing an air stream and material to be dehydrated through an acceleration channel having an inlet for receiving the air stream and material to be dehydrated, an outlet for discharging the air stream and material, and a constriction positioned between the inlet and the outlet, the air stream and material to be dehydrated  
15 having a velocity through the constriction greater than or equal to the speed of sound; and directing the discharged air stream containing dehydrated particulate material in a helical trajectory, causing the dehydrated particulate material and air stream to separate.

[0051] In some embodiments, the air stream and material to be dehydrated are directed through the acceleration channel by an air mover having an air mover inlet in  
20 communication with the outlet of the acceleration channel, the air mover drawing the air stream and material to be dehydrated in the inlet, through the acceleration channel, out the outlet and into the air mover inlet.

[0052] In some embodiments the method further comprises monitoring the velocity of the air stream through the constriction by measuring the air pressure and determining air  
25 stream velocity based on the measured air pressure, the volume of air moved per second by the air mover at the measured air pressure, and the area of the constriction.

[0053] In some embodiments, the method further comprises adjusting the velocity of the air stream to ensure the velocity through the constriction remains above the speed of sound.

30 [0054] In some embodiments, the discharged air stream containing dehydrated particulate material is directed into a cyclone in which the air stream and dehydrated particulate material move in a helical trajectory.

[0055] The present disclosure also provides a method of recovering moisture from material having a moisture content, the method comprising the steps of: directing an air  
35 stream and material to be dehydrated through an acceleration channel having an inlet for receiving the air stream and material to be dehydrated, an outlet for discharging the air stream and material, and a constriction positioned between the inlet and the outlet, the air stream and material to be dehydrated having a velocity through the constriction greater than or equal to the speed of sound; directing the discharged air stream containing  
40 dehydrated particulate material in a helical trajectory, causing the dehydrated particulate

material and air stream to separate; and directing the air stream into a moisture collector for recovering moisture from the air stream.

[0056] In some embodiments, the moisture collector is a condenser or an oil filter.

5 [0057] In some embodiments, the air stream and material to be dehydrated are directed through the acceleration channel by an air mover having an air mover inlet in communication with the outlet of the acceleration channel, the air mover drawing the air stream and material to be dehydrated in the inlet, through the acceleration channel, out the outlet and into the air mover inlet.

10 [0058] In some embodiments, the method further comprises monitoring the velocity of the air stream through the constriction by measuring the air pressure and determining air stream velocity based on the measured air pressure, the volume of air moved per second by the air mover at the measured air pressure, and the area of the constriction.

15 [0059] In some embodiments, the method further comprises adjusting the velocity of the air stream in response to the observed velocity of the air stream through the constriction, to ensure the velocity through the constriction remains above the speed of sound.

[0060] In some embodiments, the discharged air stream containing dehydrated particulate material is directed into a cyclone in which the air stream and dehydrated particulate material move in a helical trajectory.

20 [0061] The present disclosure also provides a method of disinfecting material, the method comprising directing an air stream and material to be disinfected through an acceleration channel having an inlet for receiving the air stream and material to be disinfected, an outlet for discharging the air stream and material, and a constriction positioned between the inlet and the outlet, the air stream and material to be disinfected having a velocity through the constriction greater than or equal to the speed of sound.

25 [0062] In some embodiments, the air stream and material to be disinfected are directed through the acceleration channel by an air mover having an air mover inlet in communication with the outlet of the acceleration channel, the air mover drawing the air stream and material to be dehydrated in the inlet, through the acceleration channel, out the outlet and into the air mover inlet.

30 [0063] In some embodiments the method further comprises monitoring the velocity of the air stream through the constriction by measuring the air pressure and determining air stream velocity based on the measured air pressure, the volume of air moved per second by the air mover at the measured air pressure, and the area of the constriction.

35 [0064] In some embodiments the method further comprises adjusting the velocity of the air stream to ensure the velocity through the constriction remains above the speed of sound.

[0065] In some embodiments, the discharged air stream containing disinfected particulate material is directed into a cyclone in which the air stream and disinfected particulate material move in a helical trajectory and are separated.

[0066] In some embodiments, the material to be disinfected is itself a mass of air.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5 [0067] The present disclosure is better understood having regard to the drawings in which:

[0068] Figures 1A and 1B are graphs showing temperature, pressure, and velocity of air flow through an acceleration channel of an embodiment of the present disclosure. Temperature, pressure and velocity are shown as a function of position in the acceleration channel, in the case where velocity remains below the speed of sound (Figure 1A) and in 10 the case where velocity exceeds the speed of sound (Figure 1B);

[0069] Figure 2 depicts the air velocity at different points within an acceleration chamber, during operation according to the present disclosure;

15 [0070] Figure 3 depicts an embodiment of the acceleration channel of the present disclosure, and the acoustic shockwaves that form in the area of the constriction in the acceleration channel;

[0071] Figure 4 is a cross section of an acceleration channel according to an embodiment of the present disclosure;

[0072] Figure 5 is a graphical representation of pressure drops occurring through an embodiment of an SSD system in accordance with the present disclosure;

20 [0073] Figure 6 is a graph showing certain specific characteristics of a turbine used in an embodiment of the present disclosure;

[0074] Figure 7 is a schematic view of an embodiment of the present disclosure;

[0075] Figure 8 is a further schematic view of the embodiment shown in Figure 7;

[0076] Figure 9 is a schematic view of another embodiment of the present disclosure;

25 [0077] Figure 10 is a further schematic view of the embodiment shown in Figure 9; and

[0078] Figure 11, 12 13 and 14 are schematic views of other embodiments of the present disclosure.

#### DETAILED DESCRIPTION

30 [0079] Supersonic Dehydration (SSD) is a physical process caused by induction of target material, such as organic material, into a powerful vacuum and processing through an acceleration channel. The inducted material accelerates in air from zero speed to sub-sonic speed and then passes through transonic speed to reach supersonic speed (342 meters/second and higher). The inducted matter can be any crop such as hemp, corn,

grains, seeds, fruits and nuts and plant wastes such as greenhouse plant wastes, vineyard and orchard cuttings, garden wastes, household, or industrial organic waste. As the material transitions the sound barrier it is subject to acoustic shock waves and an instant pressure drop and temperature drop occurs. The shock waves disintegrate the material and separates water and other liquids from the material and/or pulverizes solid materials such as rocks, glass, and various minerals. No heat or other form of energy is required in the process. No fossil fuels are used. No chemicals or processing agents are used.

[0080] It has also been found that small pathogens such as bacteria and viruses are not able to withstand the acoustic shock wave that disintegrates the material. In testing, a sample of animal waste inoculated with *Enterococcus faecalis* bacteria was treated using the SSD process. After two passes through the SSD process, meaning the sample was transitioned the sound barrier and was subject to acoustic shock waves twice, a reduction in the amount of live *Enterococcus faecalis* in the sample was observed. Specifically, the amount of live *Enterococcus faecalis* was observed to decrease by 3.5 log<sub>10</sub> units, or by a factor of approximately 5,000.

[0081] The powerful vacuum that accelerates material to supersonic speed can be created using aero dynamic technology to move air through the acceleration channel. Turbines are industrial products which propel large volumes of air at high velocity. They exist in many different varieties, like jet engines or industrial fans. Acceleration channel tubes, also known as venturi tubes, are also known products comprising a tube having a constriction wherein the diameter of the tube at the constriction is decreased relative to other sections of the tube, and is at a minimum at a point known as the "throat". Air or other fluids moving through such acceleration channel tubes are subject to the well-known venturi effect, wherein velocity increases, and pressure decreases as it passes through the constriction. The air (or other fluid) is moved at a velocity such that, when the air stream moves through the constriction, it accelerates to the speed of sound at a certain point in the process.

[0082] Cyclones are industrial products designed to separate particles from air or gasses, or to separate liquids with different specific weights. The principle of a cyclone is that high speed air streams containing solid particulate matter is directed into the tangent-aligned input conduit of a vertically positioned cylinder. The air and particles spin at high speed in a "tornado" vortex, having a helical trajectory. The particles of solid material drop in a downwards direction through gravitational effect and air and extracted moisture vapor exit in an upwards direction through a centrally positioned acceleration channel.

[0083] In the processing of the target material, the moisture in the material may be fully extracted from the organic material, in which situation the material will exit the cyclone in fully dried form.

[0084] In the processing of the target material, the moisture in the material may also be partially extracted from the organic material, in which situation the material will exit the cyclone as partially dried material.

[0085] In case material is not completely dried in a single pass or cycle, it can be recycled into the main material stream so the input material's moisture can be controlled in order to reach the optimal moisture level in the outgoing material.

5 [0086] Alternatively, two SSD systems may be placed in cascade in one single enclosure to process material twice (or more) to reach complete drying. In many situations, a small percentage of residual moisture is desirable for transportation or to substantially reduce the process of molding or rotting of organic materials.

[0087] Alternatively, two or more SSD systems may be placed in parallel to increase the processing capacity in one single enclosure.

10 [0088] The present disclosure is described having regard to several embodiments with reference to the Figures. While these embodiments are described generally in the context of dehydration and the applications of processing biomass, the scope of the present disclosure is not intended to be limited to the context of these applications. The present disclosure may be used in other applications and in other fields, such as pulverizing  
15 materials, disinfecting materials or air and cleaning water, effluent and other liquids, and for desalinating water.

[0089] Although the term "system" is used in this disclosure, it is not used in a limiting manner. Rather, a dehydration "system" generally includes methods, processes, structures, equipment, etc.

20 [0090] In some aspects, the present dehydration systems may be partially or fully integrated with existing systems or other third-party systems, including but not limited to feeding (in/out), grinding, shredding, cutting, pelleting or brick-making systems and/or safety systems. This integration may include one or more of the following: physical devices, power supplies, security, logging and access control devices and data and/or  
25 communication equipment.

[0091] In other aspects, the present systems provide modularity, which may increase flexibility of placement and orientation of components, increase the degree of component customization, allow for more efficient feeding and servicing of equipment, and increase efficiencies and effectiveness of operation.

30 [0092] In some embodiments, the SSD comprises one or more acceleration channels in which supersonic speed is realized by a vacuum created by one or more turbines; an acceleration channel to transport processed material into a cyclone or several cyclones to separate processed material from moist air.

35 [0093] In some embodiments, air heaters may be attached to the air stream inlet to heat and dry ingoing air.

[0094] In some embodiments, condensers may be placed after the air outlet of the cyclone to extract moisture or water from the saturated air for re-application in the irrigation chain.

[0095] In some embodiments dust traps may be placed after the air outlet to recover valuable particulate matter and condensers or oil filters may be placed after the air outlet to recover valuable vaporized plant oils, such as terpenes and aromatics.

5 [0096] The operation of SSD, and various features and components of the present disclosure are now described with reference to the Figures.

10 [0097] Figures 1A and 1B show the temperature, pressure and velocity of air flowing through an acceleration channel as part of the SSD process. These values are shown as a function of position within the acceleration channel. When air moves with subsonic speed through an acceleration channel, as shown in Figure 1A, pressure  $P$  and temperature  $T$  will go down and velocity  $v$  will go up before passing the smallest diameter (the "throat" of the acceleration channel). If velocity  $v$  does not exceed supersonic speed (Mach 1, or 342 m/s) when passing the throat, all three factors will return to their original levels after the air passed the throat and enters the diverging channel behind the throat.

15 [0098] Figure 1B shows that, when velocity  $v$  does cross the throat at supersonic speed, changes occur in the applicable laws of physics. When passing the throat, velocity  $v$  will further and dramatically increase above Mach 1 and pressure  $p$  further sinks to almost zero, creating an under-pressure close to vacuum. Temperature  $T$  continues to further decrease.

20 [0099] Figure 2 shows what happens in the acceleration channel when velocity  $v$  of air stream 550 hits Mach 1 at the throat. The applicant has used advanced academic software (Ansys 2019-R2) to simulate the development of pressure and velocity when air moves through transonic speed. At point A, an airstream is stabilized, where the velocity  $v$  of the air is forced higher at point B until it reaches the throat at point C. Air stream 550 and all material that is in it now pass the throat at transonic speed. Because of the scientifically proven effects of the transition from subsonic to supersonic speed as explained in Figures 1A and 1B, velocity  $v$  dramatically further increases at point D, while pressure  $p$  suddenly drops to near vacuum after passing the throat at point C. After reaching point E, where the original diameter is restored, speed suddenly falls back to subsonic and the vacuum is released. This combination creates strong acoustic shockwaves at line G, because of which  
25 the material disintegrates in air stream 550. With the simultaneous temperature drop creating a strong condensation, the contained moisture is absorbed by the air at point F. In this manner, wet material dries and dry air reaches 100% humidity in a fraction of a second.

35 [00100] Figure 3 shows wet material 501 moving through an embodiment of an acceleration channel 100 according to the present disclosure, from position A to position B to position C. It is generally known that a shockwave S1 is formed at the entrance to the constriction 105 of a venturi, such as acceleration channel 100. On the leading edge of the material 501 at position B, as it is moved through the acceleration channel 100, a bow wave S2 is generated. The forward surface of the material 501 at position C implodes when it hits a standing supersonic shockwave S3 at the end of constriction 105 of the acceleration channel 100. Meanwhile, additional material 501 at position B continues accelerating through recompression shock wave S1. The material 501 at position C collides in one  
40 millisecond as it transits the standing shock wave S3. Any liquid held in material 501

instantly becomes vapor. This effectively separates the water content of the wet material **501** from the rest of the material. Tests to dry various materials like corn, hemp, manure, nuts, digestate, garden waste, sewage sludge, greenhouse waste, plastics, leftover meat, dough and eggshells have all shown to be successful.

- 5    **[00101]**    Knowing the exact moisture content of the material **501**, and adjusting air velocity to adjust the bi-directional shock waves **S1**, **S2** and **S3** and “dwell time” (namely, the time required for the material **501** to enter/exit the constriction **105**) can affect the final moisture content of the material **501** leaving the acceleration channel **100**. These parameters also affect the velocity at which the material **501** exits the constriction **100b**.  
10   Ideally, the exit must happen at low velocity, which results in near-instantaneous deceleration from supersonic speed to a low speed air flow at the exit. This deceleration occurs in approximately one thousandth of one second (one millisecond). The result is that the moisture in material **501** instantaneously turns to vapor.

- 15   **[00102]**    The moisture content of the material **501** is primarily dependent on what the material is. For example, corn contains 14-16% water, whereas pre-dried pig manure still contains 60-70% water. Therefore, drying manure may require adjustments to the air velocity so as to maximize the drying effect described above. Manure may also from a “second run” through the SSD system, wherein the dried material is sent through the SSD system again to achieve further moisture removal.

- 20   **[00103]**    Another relevant variable is the humidity of the surrounding air. If it is very humid, the incoming air already contains a high percentage of moisture and therefore cannot absorb the same amount of moisture from the material as when the ambient air is dry. Therefore, System **1** from Figure **4** can include an air heater (not shown) in front of opening **104** of acceleration channel **100** to dry the incoming air stream before it is used in  
25   the drying process.

- 30   **[00104]**    Figure **4** shows a schematic view of acceleration channel **100**, in accordance with an embodiment of the disclosure. The acceleration channel comprises a cylinder **100a** having a circular cross-section whose diameter varies along its length. Cylinder **100a** has an opening **104** for allowing an air stream to enter, and an exit **110** for allowing said air stream to exit the cylinder **100a**. Since an air stream is intended to move through cylinder **100a** from its opening **104** to its exit **110**, cylinder **100a** can be said to have an “upstream end” at its opening **104**, and a “downstream end” at its exit **110**. Cylinder **100a** can be made of any material of suitable strength to withstand the forces arising through operation of the SSD, for example, polypropylene, reinforced polyester, carbon fiber, stainless steel, or  
35   a combination of these materials. In the illustrated embodiment, cylinder **100a** is a stainless steel pipe having 4mm thick walls.

- 40   **[00105]**    Acceleration channel **100** comprises a constriction **100b**, which is a segment of acceleration channel **100** along which the diameter of the acceleration channel **100** decreases, and then increases back to its original value. The constriction **100b** comprises: (a) an inclination section **105**, along which the diameter of the channel **100** decreases; (b) a throat **106** immediately downstream from inclination section **105**, the throat **106** being the point where the diameter of the channel **100** is at its lowest; and (c) a widening section **107** immediately downstream from throat **106**, along which the diameter of the channel

**100** increases once again. The inner surface of cylinder **100a** at the junctions between inclination section **105**, throat **106** and widening section **107** may be sharp edged or may be rounded off.

5     **[00106]**     In the illustrated embodiment, constriction **100b** is formed using a polypropylene form, inserted into cylinder **100a**, and having the specific geometry required to form the constriction **100b** as described above. It will be understood, however, that constriction **100b** could also be formed integrally with cylinder **100a**. In other words, cylinder **100a** can have interior walls dimensioned so as to form the constriction **100b** described above.

10     **[00107]**     Acceleration channel **100** also comprises an air pressure sensor **109** mounted downstream from the throat **106**. Air pressure sensor **109** is used in the measurement of the velocity of the airstream through the acceleration channel **100**, in the manner described in detail below. Air pressure sensor **109** can be any device widely known and available that is capable of obtaining a measurement of air pressure. Air pressure sensor  
15     **109** can be mounted to acceleration channel **100** in any manner suitable to allow for the measurement of air pressure within the channel **100** downstream from the throat **106**.

20     **[00108]**     Although the SSD process can be achieved using any sort of acceleration channel having a constriction, also known as a venturi tube, the particular dimensions of the acceleration channel will affect the velocity at which air moves through the channel. Accordingly, the geometry of the acceleration channel can be designed to provide the required air velocity (namely, transonic speed or better at the throat of the constriction) using a relatively low input air velocity.

25     **[00109]**     By way of example, acceleration channel **100** can have the following dimensions:

30     an interior diameter of 160mm at all points outside the constriction **100b**;  
a length from opening **104** to the beginning of the constriction **100b** of at least 400mm;  
an inclination section **105** having a length from its beginning to its end at throat **106** of between 100mm and 400mm;  
35     a widening section **107** having a length from its beginning at throat **106** to its end at exit **110** of between 60 and 120mm; and  
a diameter of the channel **100** at throat **106** that is between 2.5 times smaller and 10 times smaller than the interior diameter of the acceleration channel **100**, depending on the type and design of the turbine moving air through the acceleration channel **100**.

40     **[00110]**     Dimensions within the ranges outlined above have been observed to provide the air velocity required for the SSD process (i.e., an air velocity at or above the speed of sound at the throat **106**) and successfully dry and disinfect materials. The dimensions of the acceleration channel **100** can be further designed such that air velocities at or above

the speed of sound at the throat **106** can be achieved as efficiently as possible, namely, with the lowest possible input air velocity. For example, adjustments to the ratio of the throat diameter to the acceleration channel interior diameter can change the airstream velocity through the throat **106**, as well as the input airstream velocity required to achieve  
5 supersonic airstream velocity through the throat **106**.

[00111] The design of the dimensions of acceleration channel **100** can also provide other positive effects. For example, providing at least **400mm** from the opening **104** to the beginning of inclination section **105** allows the air stream entering the opening **104** to stabilize before entering the constriction **100b**. As another example, the shorter the  
10 widening section **107** is made relative to the inclination section **105**, the faster the deceleration of the air stream and material will be, making the drying and disinfecting properties of the SSD process more effective.

[00112] It is apparent from the foregoing that the SSD process requires that air stream velocity through the throat **106** be at least the speed of sound (342 m/s), or higher. While  
15 air stream velocity is commonly measured using pitot tubes, pitot tubes are not suitable for use in turbulent, supersonic environments such as that which exists in the vicinity of the throat **106** when an airstream is moving through channel **100** at high velocity. The velocity of the airstream can instead be measured indirectly by measuring air pressure immediately downstream from the throat **106**, using air pressure sensor **109**. Using the  
20 measured air pressure in this region in combination with known characteristics of the turbine used to generate the airstream through the channel **100** (described in greater detail below), the airstream velocity can be calculated.

[00113] Figure 5 is a graphical representation of the basic air pressure drop over the entire SSD system 1 (shown in Figures 7 and 8 and described in greater detail below) after  
25 throat **106**.  $\Delta p_v$  **001** is the pressure drop measured by sensor **109**, after the throat **106**.  $\Delta p_t$  **002** is the pressure drop over conduit **300** (shown in Figures 7 and 8 and described in greater detail below), and  $\Delta p_c$  **003** is the pressure drop over cyclone **400** (shown in Figures 7 and 8 and described in greater detail below). In the illustrated embodiment,  $\Delta p_t$  **002** and  $\Delta p_c$  **003** are not measured. Rather, industry best  
30 estimates of fixed pressure drops 1000 Pa are used. It will be understood that, for more accurate measurement of airstream velocity through the throat **106**, additional air pressure sensors could be added to measure  $\Delta p_t$  **002** and  $\Delta p_c$  **003** directly. Accordingly, it can be seen that the total pressure drop over the entire system is the sum of  $\Delta p_v$  **001**,  $\Delta p_t$  **002** and  $\Delta p_c$  **003**.

[00114] Figure 6 shows certain specific characteristics of an embodiment of turbine **200**  
35 used to create the air stream through channel **100**, as described in greater detail below. In particular, Figure 6 shows both the under pressure generated by the turbine and the power consumed by the turbine's motor, as a function of air volume moved by the turbine per second. Curve **011a** shows the relation between negative pressure generated by the  
40 turbine, and the volume of air moved through the turbine. Curve **011b** shows the relation between turbine motor power and the volume of air moved through the turbine. Such characteristics are commonly available from manufacturers of turbines.

[00115] The calculation of air stream velocity at throat **106** will be shown by way of example. For the purpose of this example, it will be assumed that SSD system **1** has been operated having an observed total air pressure drop (that is, the sum of delta  $p_v$  **001**, delta  $p_t$  **002**, and delta  $p_c$  **003**) of 29,800 Pa, or 298 millibar). This represents a measured  
 5 pressure drop delta  $p_v$  **001** of 27,800 Pa, and best estimate values of 1000 Pa for each of delta  $p_t$  **002**, and delta  $p_c$  **003**.

[00116] Figure 6 shows that, at this under-pressure, the turbine processes 1.5 cubic meter of air per second, and uses approximate 78 kW of power. Knowing the volume of air moving through the system per second, as well as the diameter of the throat **106**, the  
 10 airstream velocity through the throat **106** can be calculated. Using a throat having a diameter of 70mm, the total area of the throat can be calculated as  $\pi * \left(\frac{d}{2}\right)^2$ , which equals 0.0038m<sup>2</sup> in this case. Airstream velocity can therefore be calculated as 1.5 m<sup>3</sup>/s ÷ 0.0038m<sup>2</sup> = 390 m/s. This airstream velocity is sufficiently above the speed of sound for the SSD process to function.

[00117] Figure 7 shows an SSD system **1** that uses acceleration channel **100** for drying and disinfecting material using the SSD process. SSD system **1** has a collector frame **101** attached to the acceleration channel **100** to allow input of material to be dried and disinfecting from larger collector entrance **102** into acceleration channel **100** via material  
 15 entrance **103**. Collector **101** can have an integrated shredder (not shown) for reducing the particulate size of incoming material to be dried and disinfected.

[00118] Acceleration channel **100** comprises entrance **104** adapted to allow air to be drawn into channel **100** during operation. The particular shape of entrance **104** shown in Figure 7 is not essential but enhances the ability of air to be sucked into acceleration channel **100**.

[00119] At exit **110** of acceleration channel **100**, the channel **100** is connected to intake **201** of turbine **200**, allowing air passing through the channel to enter the turbine **200**. Turbine **200** comprises rotor blades **203** on axis **202**. Turbine **200** can be driven by any kind of motor, although electrical motors are preferred. Turbine **200** has outlet **204** connected to tube system **300**, allowing an air entering the turbine **200** from the acceleration channel  
 30 **100** to continue onward to tube system **300**. Turbine **200** can be any commercially available turbine capable of producing air pressures and air flow sufficient to produce air velocity at or in excess of the speed of sound at the throat **106** of acceleration channel **100**. A turbine capable of creating under pressure at its intake in the range of -290 millibar to -390 millibar, and air flow capacity of 1.5 m<sup>3</sup> per second to 1.66 m<sup>3</sup> per second, has been observed to be  
 35 effective in generating the required airstream velocity through acceleration channel **100**.

[00120] Tube system **300** comprises tube **301** and exit **302** creating a path for airflow from the turbine outlet **204** to cyclone **400**. Tube **301** and exit **302** can have cylindrical, elliptical, or rectangular cross sections, which may also vary along the length of tube system **300**. Exit **302** of tube system **300** is connected the top side of circular cyclone **400**, where  
 40 the entrance is aligned on a tangent to the circular cross-section of the hull **401** of cyclone **400**. An airstream and materials entering cyclone **400** via the entrance is directed on a tornado-like helical trajectory within the hull **401**. Heavier particles of material within the

helically moving airstream, such as dried and disinfected material, will move downward in the hull **401**, where they will collect at exit **403** and can be recovered from the cyclone **400** through rotating airlock **404**. Lighter materials in the helically moving airstream, such as the moisture laden air received from the acceleration channel **100** and turbine **200**, can exit the cyclone **400** through opening **402**.

[00121] Cyclone **400** can be dimensioned to filter out particles above any specified diameter. It is generally known that the dimensions of cyclones are based on the level of desired separation of dust or solid material from air. The dimensions of cyclone **400** can therefore be selected as appropriate for the given application.

10 [00122] Figure 8 shows the flow of air and material to be dried and disinfected through the SSD system **1**. Turbine **200** is operated at a power level and under pressure value sufficient to produce an airstream velocity through throat **106** that is equal to or greater than the speed of sound. The airstream velocity through throat **106** can be verified using pressure measurements taken downstream from throat **106**, in the manner described above.

15 [00123] When turbine **200** is operated as described above, dry air **550** is pulled into Acceleration Channel **100** through entrance **104**. Material to be dried and disinfected **501** is added through entrance **102** and falls into the airstream **550**. Material **501** can be added through entrance **102** via an automated conveyor system (not shown) that drops material **501** through entrance **102**. The operation of this conveyor system can be triggered by the airstream velocity measurement taken indirectly via the air pressure measurement recorded by sensor **109**. In particular, once the pressure measured by sensor **109** indicates that airstream velocity through the throat **106** is at the speed of sound or greater, the conveyor system can be activated. This activation can be achieved automatically, by way of control software interconnecting sensor **109** and the conveyor system.

20 [00124] Material **501** and airstream **550** are accelerated towards the speed of sound, moving downstream through cylinder **100a** and inclination section **105** towards the throat **106**. If the distance from opening **104** to the beginning of the constriction **100b** is sufficient to allow the airstream **550** to stabilize before it enters the constriction **100b** (400mm in the illustrated embodiment), material **501** will be flowing smoothly down the middle of cylinder **100a**, and not interacting with the side walls of cylinder **100a** by the time the material enters the constriction **100b**.

25 [00125] As airstream **550** and material **501** transit the throat **106**, they accelerate past the speed of sound. Material **501** is subjected to the acceleration and acoustic shock waves described above, the result being that material **501** is disintegrated, moisture comes out of material **501**, and the airstream **550** reaches 100% humidity in a fraction of a second.

30 [00126] Disintegrated material **501** and humid airstream **550** exit the acceleration channel **100** and move through turbine **200** and tube system **300** to reach cyclone **400**. Material **501** and airstream **550** then begin moving in a helical trajectory within hull **401** of cyclone **400**. Disintegrated, dried and disinfected material **501** falls downward to exit **403** where it can be retrieved. In the embodiments shown in Figures 7 and 8, rotating airlock

**404** can selectively seal off exit **403** or permit material **501** to exit the cyclone **400**. Bin **406** can be provided to collect the disintegrated, dried, and disinfected material **501**.

[00127] Figures 9 and 10 show another embodiment of the SSD system 2. SSD system 2 is substantially the same as SSD system 1, but with the addition of a loop-back channel **304**.  
5 Loop-back channel **304** can be a conveyor belt, or any other suitable means for transporting dried and disinfected material **501** back to opening **102** for a "second run" through the SSD system, where it can be further dried and disinfected.

[00128] Figure 11 shows a further embodiment of the present disclosure, wherein two or more SSD systems 1 can be arranged in series. Exhaust moisture and air **550** leaves cyclone **400** of SSD system 1 on exit **402**, and dried, disinfected material **501** leaves cyclone **400** at exit **403**. Upon exit, dried and disinfected material **501** is directly fed into another SSD system 1, for further drying and disinfection. It will be apparent that as many SSD systems 1 as may be needed can be arranged in series in this manner.  
10

[00129] Figure 12 shows a schematic setup of a basic SSD system with two cyclones in cascade, where, after the first separation of solid product from moist air, the second cyclone can separate finer particles which were not separated by the first cyclone.  
15

[00130] Figure 12 shows another embodiment of the present disclosure, where a SSD system 1 is provided with two cascaded cyclones **400** and **400b**. Exhaust moist air **550** moves through conduit **300b** into cyclone **400b**, where finer particles **503** leave at exit **403b**, and moist air **550** leaves at exhaust **402b**. The dimensioning of cyclone **4b** is tailored towards the mesh size of leftover particles in exhaust moist air **550"**, which depends on the material being processed.  
20

[00131] Figure 13 shows a further embodiment of the present disclosure wherein residual water collected from bio waste that has been dried (for example, tomato plants after tomatoes are harvested) is directly added to an irrigation water basin in or outside the greenhouse after being processed by SSD.  
25

[00132] Figure 13 shows an SSD system 1 where solid and partly dried material leaves cyclone **400** at exit **403** and can be collected in a bin **406**.

[00133] Figure 13 also shows exhaust moisture and air **550** leaving SSD system 1 through tube system **300c**. The moisture contained in air **550** can be water or other liquid extracted from the material **501** by way of the SSD process. Such other liquids can include hemp oils or other oils, depending on the type of material **501** being dried. Air stream **550** containing the moisture extracted from material **501** can be fed into moisture collector **801**, for the purpose of recovering the moisture. Moisture collector **801** can be any of a number of known technologies for extracting liquid water or other liquids from humid, moisture-laden air. In the illustrated embodiment, moisture collector **801** is a condenser for extracting liquid water from humid air, and water droplets **551** collected from the condenser are deposited in tank **802** to be transported through channel **803** as irrigation water. In other embodiments, moisture collector **801** can be an oil filter, for filtering and collecting oil particles released into air stream **550** by the SSD process. In other embodiments, both a condenser and an oil filter can be used.  
30  
35  
40

[00134] **Figure 14** shows a another embodiment of the present disclosure wherein acceleration channel **100** has no collector, and material **501** is sucked into opening **104** of acceleration channel **100** directly by the airstream created by turbine **200** from e.g. an external collector belt or other mechanical transportation or feeding system (not shown).

5 [00135] From the foregoing, numerous advantages of the SSD process will be apparent. The SSD can be used to dry bulk material, reducing its weight and volume and thus making it easier and less expensive to transport. The SSD accomplishes this while consuming approximately 100kW of power to process approximately 2 metric tons of material per hour. This is less than 25% of the power consumption required to operate traditional fossil  
10 fuel-based systems for drying waste. As well, the carbon footprint of the SSD system is much smaller than that of traditional heat-based drying systems, since SSD uses only an electric motor. Furthermore, since an SSD system can operate with minimal maintenance and supervision, the operation cost of an SSD system will be lower than that of conventional drying systems.

15 [00136] As well, the SSD system can accomplish the drying and disinfection of bulk organic material without using any heat, and without the addition of any viscosity modifying agent.

[00137] Accordingly, the present structures and systems may provide for supersonic dehydration systems and structures, improved customization of types and positioning of  
20 various equipment, and improved ease of access to equipment for maintenance.

[00138] The structure, features, accessories, and alternatives of specific embodiments described herein and shown in the Figures are intended to apply generally to all the teachings of the present disclosure, including to all the embodiments described and illustrated herein, insofar as they are compatible. In other words, the structure, features,  
25 accessories, and alternatives of a specific embodiment are not intended to be limited to only that specific embodiment, unless so indicated.

[00139] Furthermore, additional features and advantages of the present disclosure will be appreciated by those skilled in the art. By way of example, tube system **300** that carries humid airstream and dried material to cyclone **400** and connect to two or more cyclones  
30 **400**, as permitted by the physical space available on site, to increase the capacity of the SSD system. As well, cyclone **400** can contain dust filters, for example, HEPA filters (not shown) to capture very fine particles of dried, disinfected material.

[00140] In addition, the embodiments described herein are examples of structures, systems or methods having elements corresponding to elements of the techniques of this application. This written description may enable those skilled in the art to make and use  
35 embodiments having alternative elements that likewise correspond to the elements of the techniques of this application. The intended scope of the techniques of this application thus includes other structures, systems or methods that do not differ from the techniques of this application as described herein, and further includes other structures, systems or  
40 methods with insubstantial differences from the techniques of this application as described herein.

[00141] Moreover, the previous detailed description is provided to enable any person skilled in the art to make or use the present invention. Various modifications to those embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention described herein. Thus, the present invention is not intended to be limited to the embodiments shown herein, but is to be accorded the full scope consistent with the claims, wherein reference to an element in the singular, such as by use of the article "a" or "an" is not intended to mean "one and only one" unless specifically so stated, but rather "one or more". All structural and functional equivalents to the elements of the various embodiments described throughout the disclosure that are known or later come to be known to those of ordinary skill in the art are intended to be encompassed by the elements of the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims.

15

**WHAT IS CLAIMED IS:**

1. An apparatus for dehydrating or disinfecting material, the apparatus comprising:
  - an acceleration channel having an inlet for receiving an air stream and material to be dehydrated, an outlet for discharging said air stream and dehydrated, disinfecting material, and a constriction positioned between the inlet and the outlet;
  - an air mover in communication with the acceleration channel for moving an air stream and material to be dehydrated through the acceleration channel such that the velocity of the air stream and material moving through the constriction is equal to or greater than the speed of sound; and
  - a cyclone in communication with the outlet of the acceleration channel for receiving said discharged air stream and dehydrated, disinfecting material, and separating said dehydrated, disinfecting material from said air stream.
2. The apparatus of claim 1, wherein the constriction is positioned at least 400 millimeters from the inlet of the acceleration channel.
3. The apparatus of claim 1 or claim 2, wherein the constriction comprises:
  - an inclination section, along the length of which the diameter of the acceleration channel decreases;
  - a widening section, along the length of which the diameter of the acceleration channel increases; and
  - a throat, located at a point between the inclination section and the widening section where the diameter of the acceleration channel is smallest.
4. The apparatus of claim 3, wherein the length of the inclination section is within the range of 100 millimeters and 400 millimeters.
5. The apparatus of claim 3 or claim 4 wherein the length of the widening section is within the range of 60 millimeters and 120 millimeters.
6. The apparatus of any one of claims 3-5 wherein the ratio of the diameter of the acceleration channel at the throat, to the maximum diameter of the acceleration channel is within the range of 1:2.5 to 1:10.
7. The apparatus of any one of claims 1 to 6, wherein the acceleration channel has an interior diameter of about 160 millimeters at all points outside the constriction.
8. The apparatus of any one of claims 1 to 7 wherein an intake of the air mover is in communication with the outlet of the acceleration channel, and the cyclone is in communication with an outlet of the air mover.

9. The apparatus of any one of claims 1 to 8, wherein the air mover is a turbine capable of generating under pressure in the range of -290 millibar to -390 millibar, and airflow capacity in the range of 1.5 m<sup>3</sup> per second to 1.66 m<sup>3</sup> per second.
10. The apparatus of any one of claims 1 to 9, further comprising an air pressure sensor in communication with the acceleration channel, for measuring air pressure within the channel.
11. A method of dehydrating material, the method comprising the steps of:
- directing an air stream and material to be dehydrated through an acceleration channel having an inlet for receiving the air stream and material to be dehydrated, an outlet for discharging the air stream and material, and a constriction positioned between the inlet and the outlet, the air stream and material to be dehydrated having a velocity through the constriction greater than or equal to the speed of sound; and
- directing the discharged air stream containing dehydrated particulate material in a helical trajectory, causing the dehydrated particulate material and air stream to separate.
12. The method of claim 11, wherein the air stream and material to be dehydrated are directed through the acceleration channel by an air mover having an air mover inlet in communication with the outlet of the acceleration channel, the air mover drawing the air stream and material to be dehydrated in the inlet, through the acceleration channel, out the outlet and into the air mover inlet.
13. The method of any one of claims 11 or 12 further comprising monitoring the velocity of the air stream through the constriction by measuring the air pressure and determining air stream velocity based on the measured air pressure, the volume of air moved per second by the air mover at the measured air pressure, and the area of the constriction.
14. The method of claim 13, further comprising adjusting the velocity of the air stream in response to the observed velocity of the air stream through the constriction, to ensure the velocity through the constriction remains above the speed of sound.
15. The method of any one of claims 11-14 wherein the discharged air stream containing dehydrated particulate material is directed into a cyclone in which the air stream and dehydrated particulate material move in a helical trajectory.
16. A method of recovering moisture from material having a moisture content, the method comprising the steps of:
- directing an air stream and material to be dehydrated through an acceleration channel having an inlet for receiving the air stream and material to be dehydrated, an outlet for discharging the air stream and material, and a constriction positioned between the inlet and the outlet, the air stream and material to be dehydrated

- having a velocity through the constriction greater than or equal to the speed of sound;
- directing the discharged air stream containing dehydrated particulate material in a helical trajectory, causing the dehydrated particulate material and air stream to separate; and
- directing the air stream into a moisture collector for recovering moisture from the air stream.
17. The method of claim 16, wherein the moisture collector is a condenser or an oil filter.
18. The method of claim 16 or 17, wherein the air stream and material to be dehydrated are directed through the acceleration channel by an air mover having an air mover inlet in communication with the outlet of the acceleration channel, the air mover drawing the air stream and material to be dehydrated in the inlet, through the acceleration channel, out the outlet and into the air mover inlet.
19. The method of any one of claims 16 - 18 further comprising monitoring the velocity of the air stream through the constriction by measuring the air pressure and determining air stream velocity based on the measured air pressure, the volume of air moved per second by the air mover at the measured air pressure, and the area of the constriction.
20. The method of claim 19, further comprising adjusting the velocity of the air stream to ensure the velocity through the constriction remains above the speed of sound.
21. The method of any one of claims 16-20 wherein the discharged air stream containing dehydrated particulate material is directed into a cyclone in which the air stream and dehydrated particulate material move in a helical trajectory.
22. A method of disinfecting material, the method comprising:
- directing an air stream and material to be disinfected through an acceleration channel having an inlet for receiving the air stream and material to be disinfected, an outlet for discharging the air stream and material, and a constriction positioned between the inlet and the outlet, the air stream and material to be disinfected having a velocity through the constriction greater than or equal to the speed of sound.
23. The method of claim 22 wherein the air stream and material to be disinfected are directed through the acceleration channel by an air mover having an air mover inlet in communication with the outlet of the acceleration channel, the air mover drawing the air stream and material to be dehydrated in the inlet, through the acceleration channel, out the outlet and into the air mover inlet.
24. The method of any one of claims 22 or 23 further comprising monitoring the velocity of the air stream through the constriction by measuring the air pressure and determining air stream velocity based on the measured air pressure, the volume of air

moved per second by the air mover at the measured air pressure, and the area of the constriction.

25. The method of claim 24, further comprising adjusting the velocity of the air stream to ensure the velocity through the constriction remains above the speed of sound.

- 5 26. The method of any one of claims 22-25 wherein the discharged air stream containing disinfected particulate material is directed into a cyclone in which the air stream and disinfected particulate material move in a helical trajectory and are separated.

27. The method of any of claims 22-26, wherein the material to be disinfected is an air mass.

FIGURE 1A

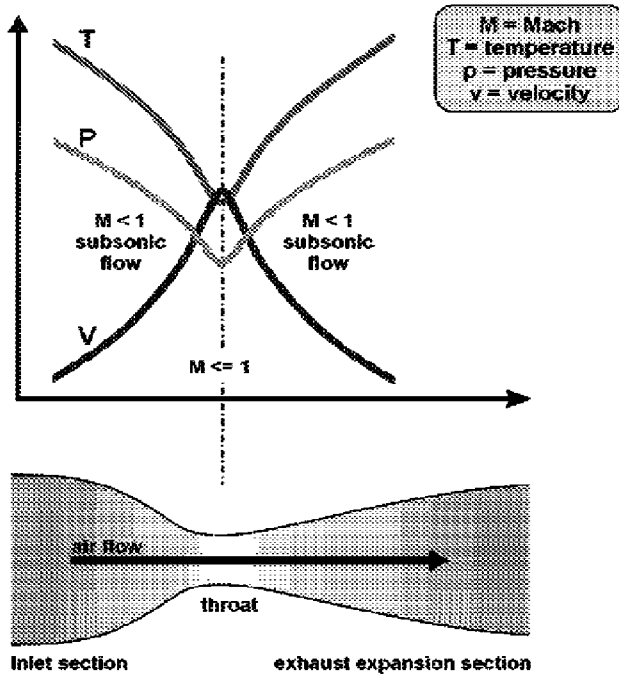


FIGURE 1B

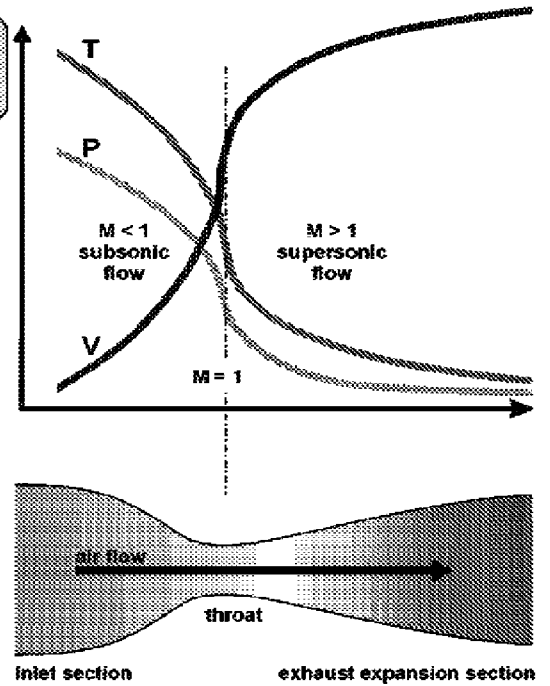


FIGURE 2

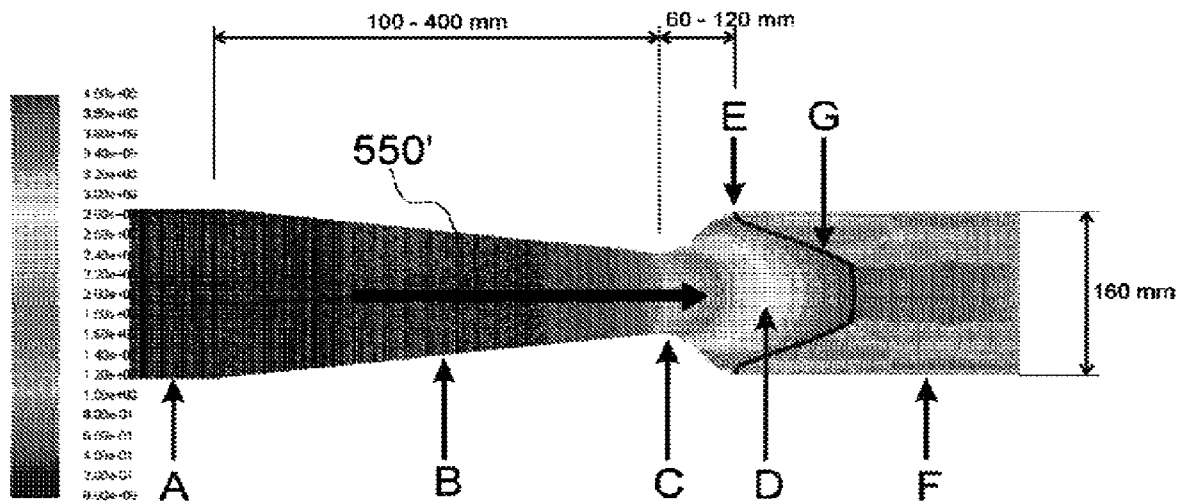


**FIGURE 3**

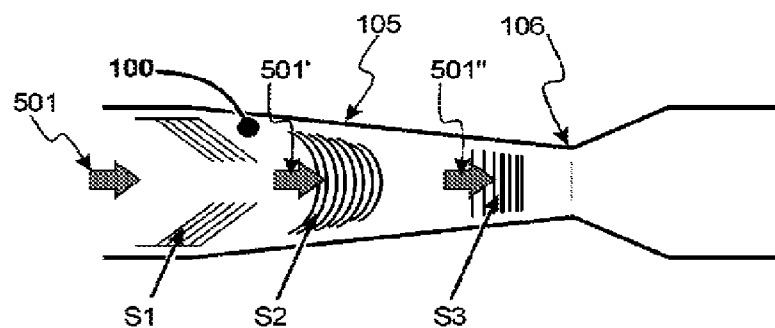
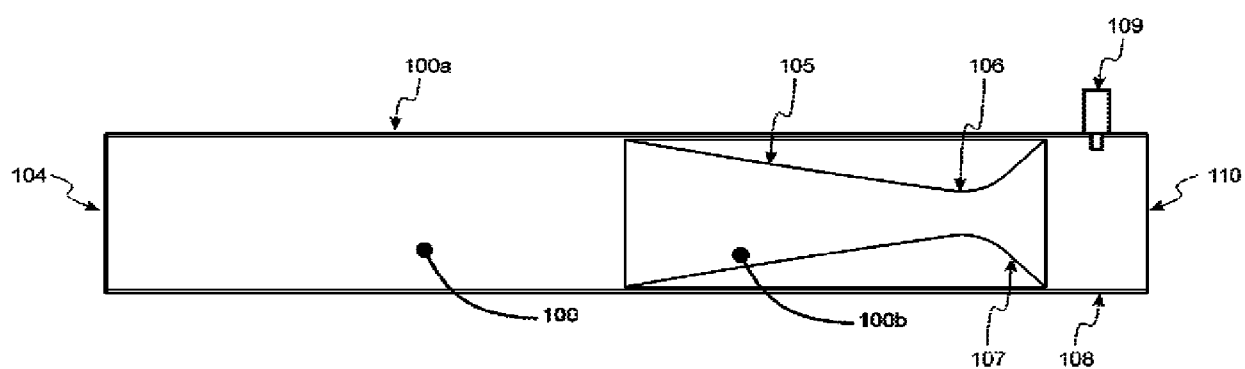
**FIGURE 4**

FIGURE 5

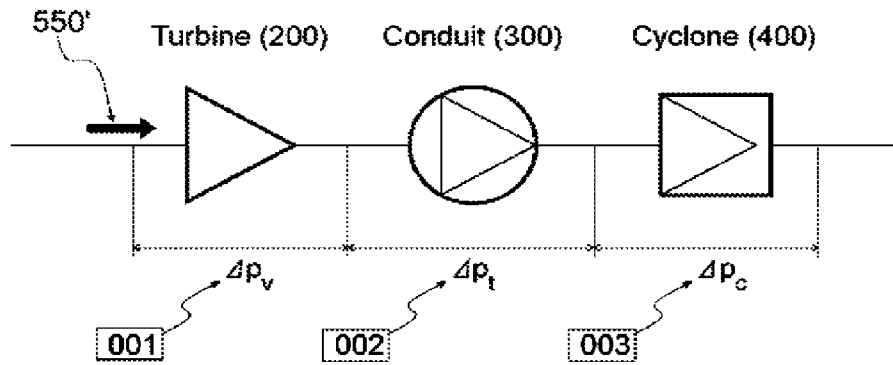


FIGURE 6

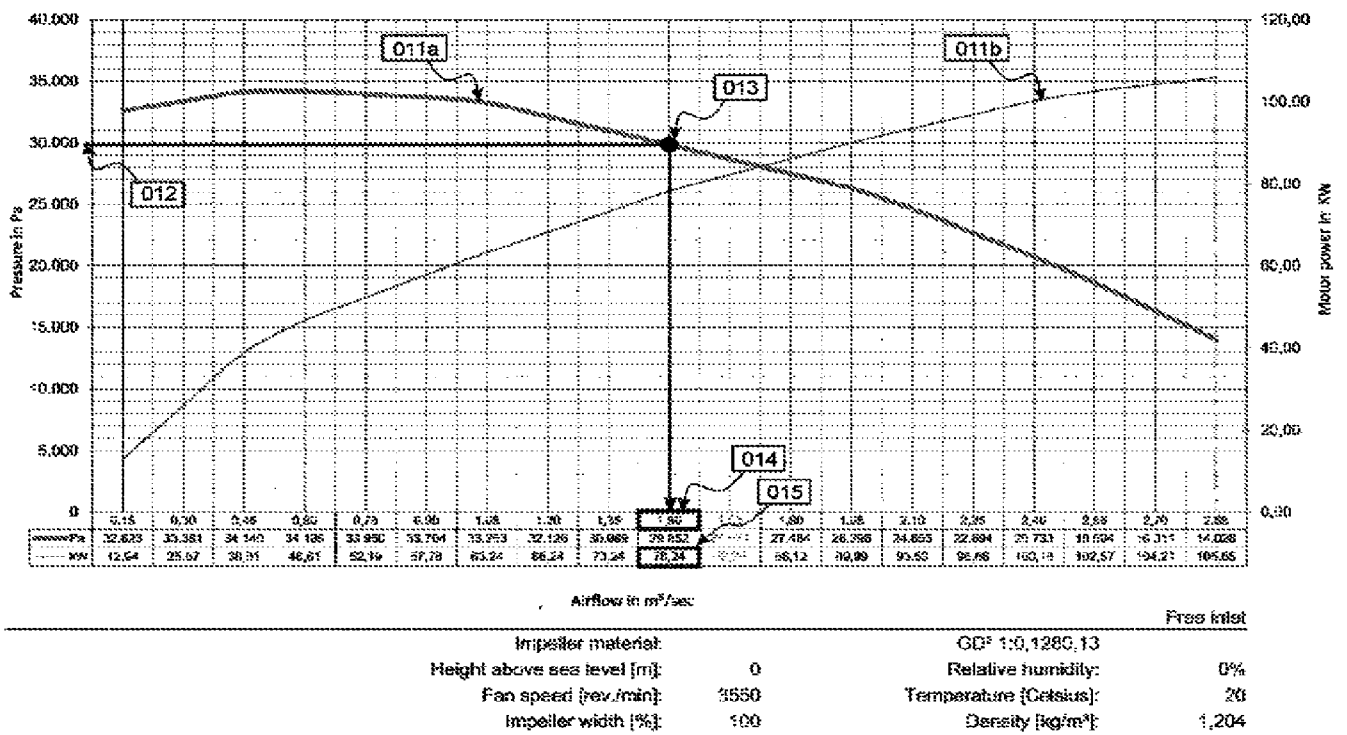


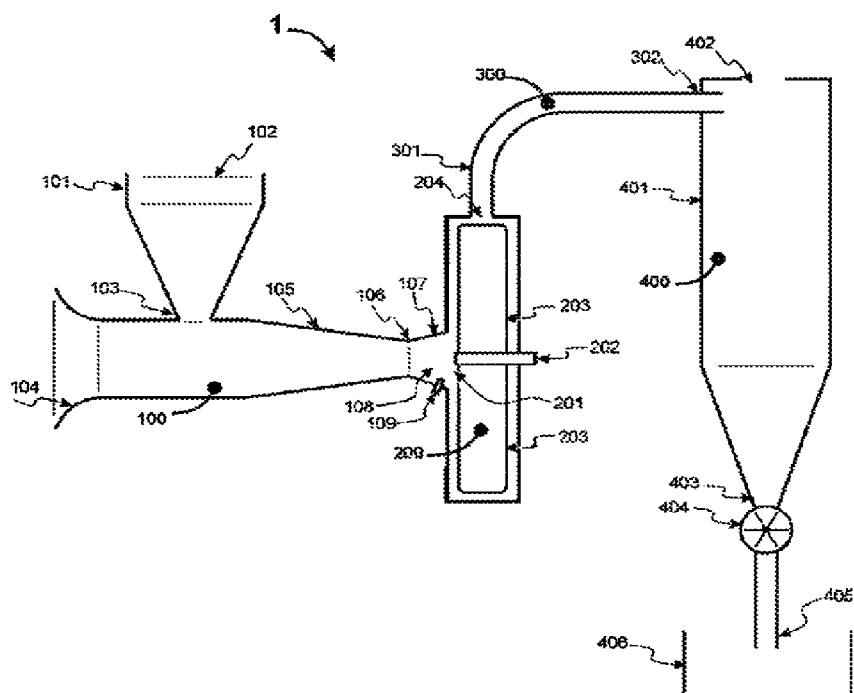
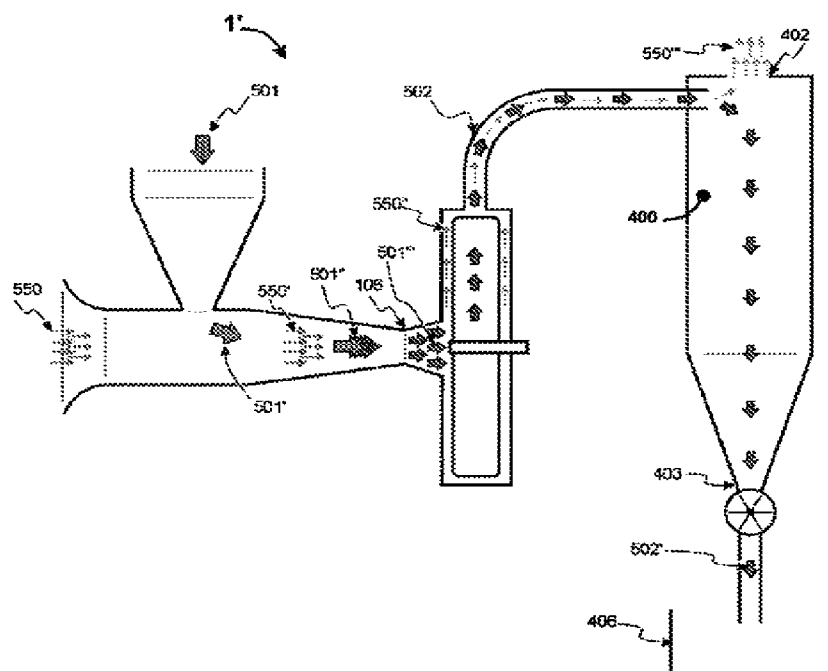
**FIGURE 7****FIGURE 8**

FIGURE 9

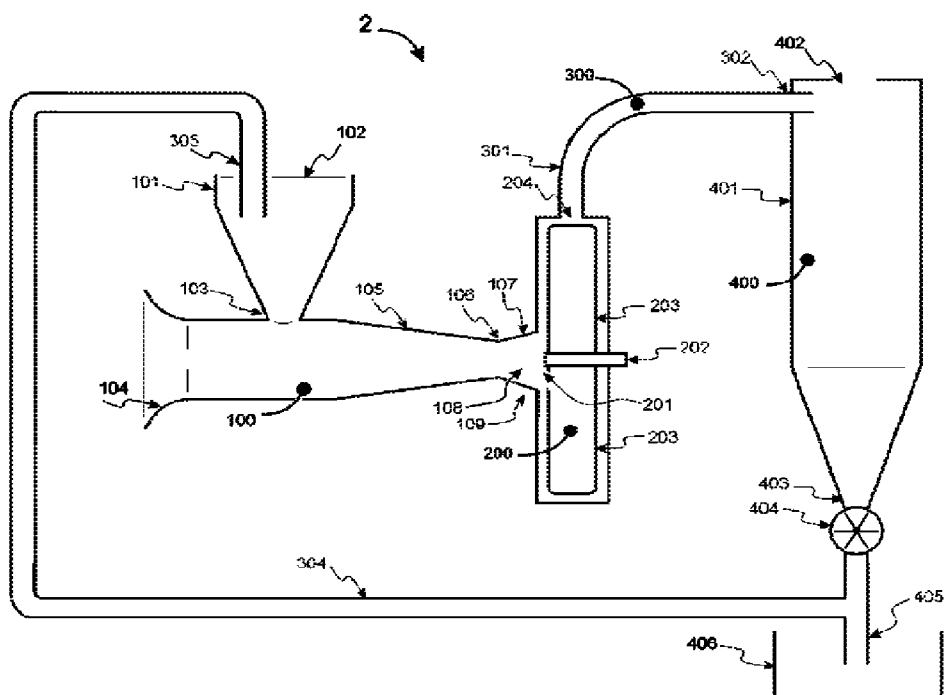


FIGURE 10

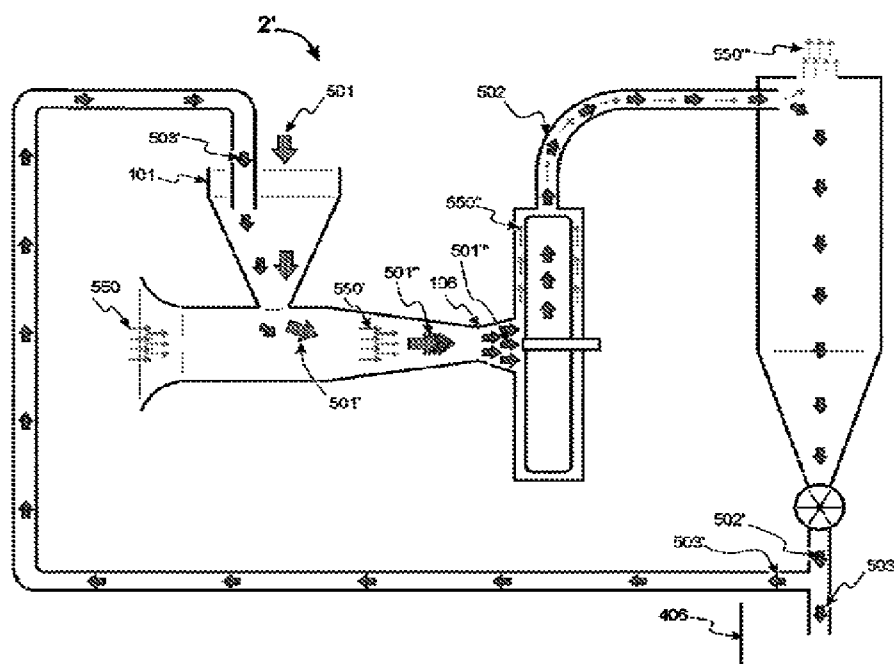


FIGURE 11

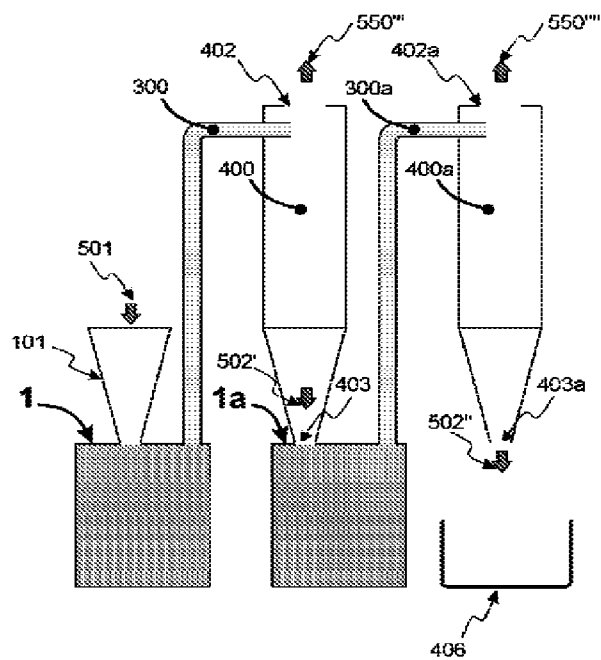


FIGURE 12

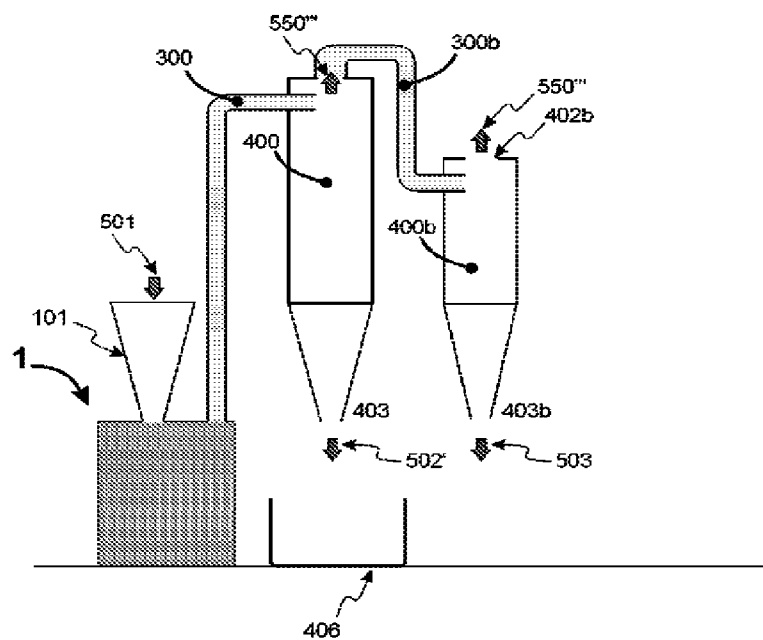


FIGURE 13

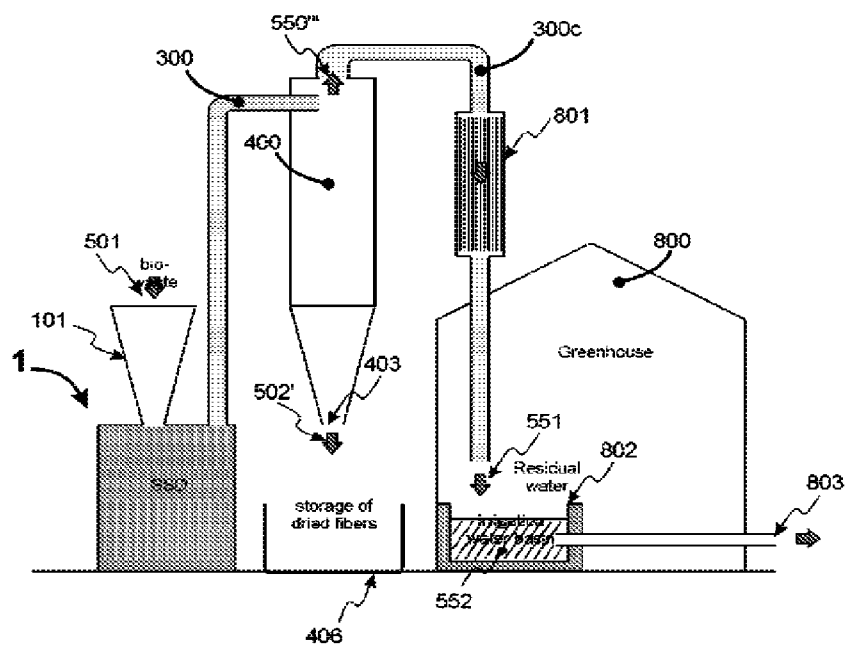


FIGURE 14

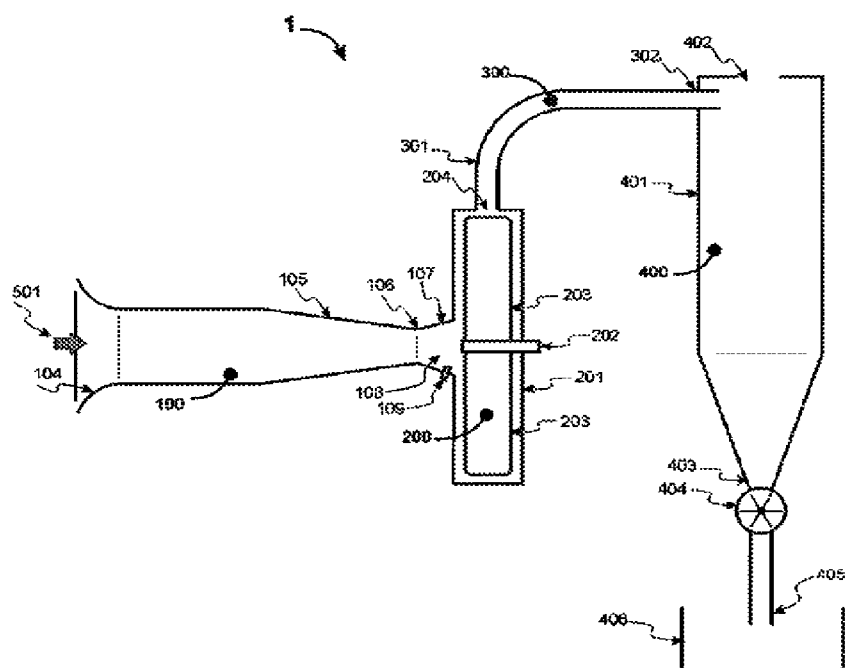


**FIGURE 1A**

