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(71) Applicant(s):
Simon Surinder Pal Grewal
336 Cranbrook Road, Grants Hill, Ilford, Essex, IG2 6EP, United Kingdom

(72) Inventor(s):
Simon Surinder Pal Grewal

(74) Agent and/or Address for Service:
N E Parker & Co
3rd Floor Townend House, Park Street, WALSALL, West Midlands, WS1 1NS, United Kingdom

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(56) Documents Cited:
EP 0040887 A **US 7527734 B1**
US 5288462 A **US 1728333 A**
US 1711097 A

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(54) Title of the Invention: **Improvements in or relating to decontamination**
Abstract Title: **Antimicrobial decontamination method comprising reducing pressure sufficiently quickly to kill microorganisms**

(57) An antimicrobial decontamination method of treatment comprising the steps of placing an article, item or liquid to be treated in a pressure vessel 12 and reducing the pressure in the vessel sufficiently quickly to kill microorganisms or at least inhibit microorganisms from reproducing. In one embodiment, gas is introduced into the vessel 12 such that a proportion of the gas diffuses into the microorganisms through their pores. In another embodiment, the pressure is reduced at such a speed to substantially evaporate or flash boil at least a layer of moisture on the surface of the article, item or liquid which thereby leads to a reduction in temperature. Also claimed is an apparatus for carrying out the microbial decontamination method comprising a pressure vessel 12, a pressurising means, and a pressure release means. Preferably the gas is an inert gas such as helium or hydrogen. A second pressurising gas, such as nitrogen, may also be introduced into the vessel 12. The pressure may be increased to above 400 kPa for about 20 seconds, and the pressure may be released or reduced within a period of less than 1 second.

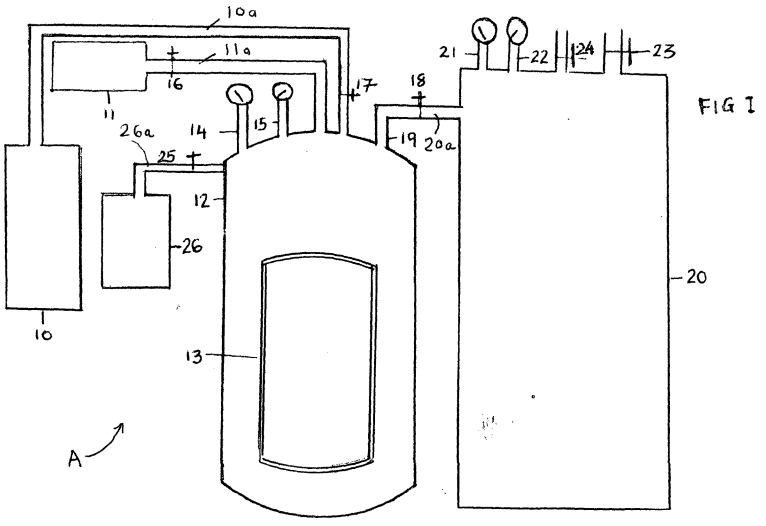

FIG 1

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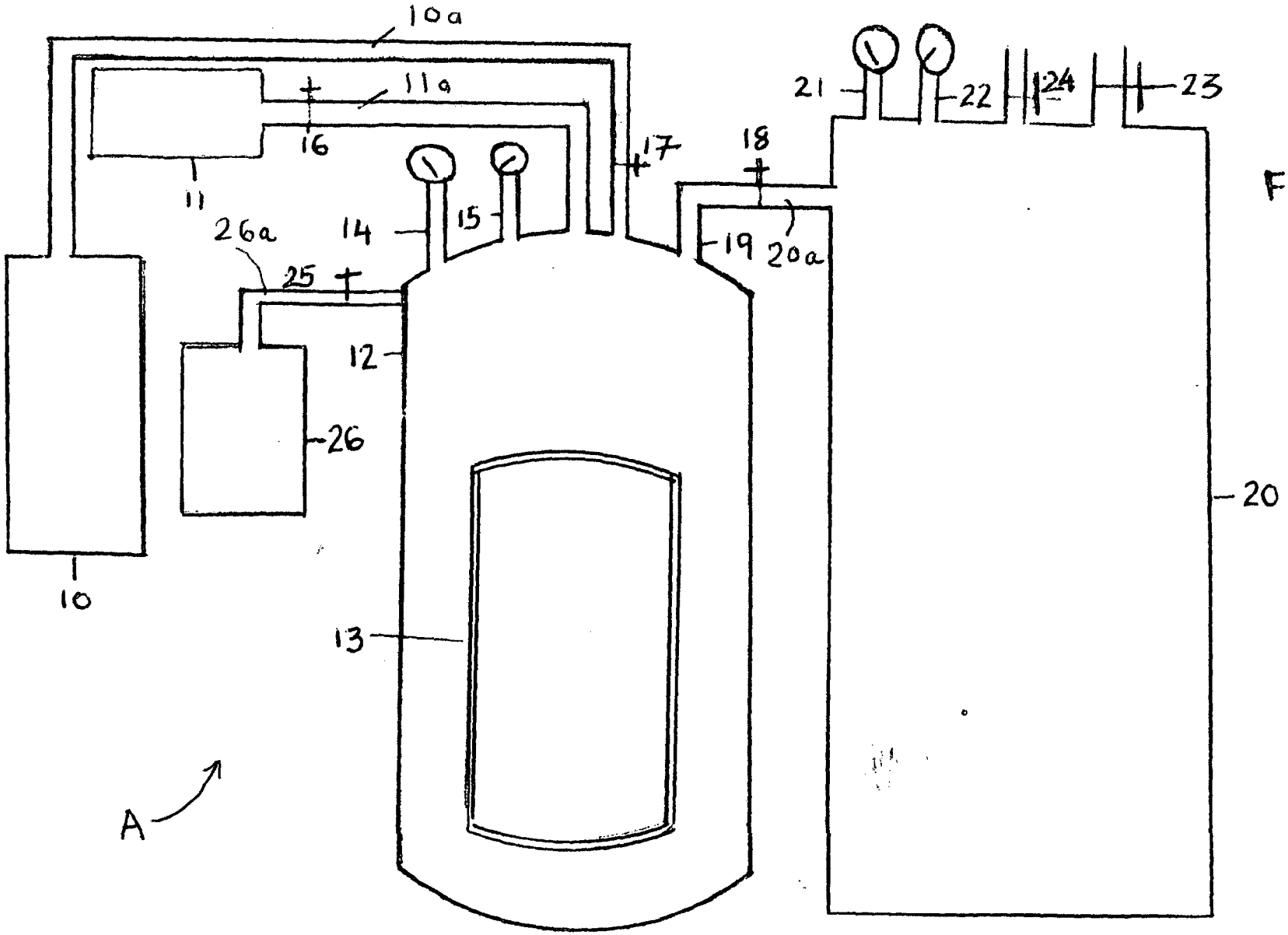

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FIG 1

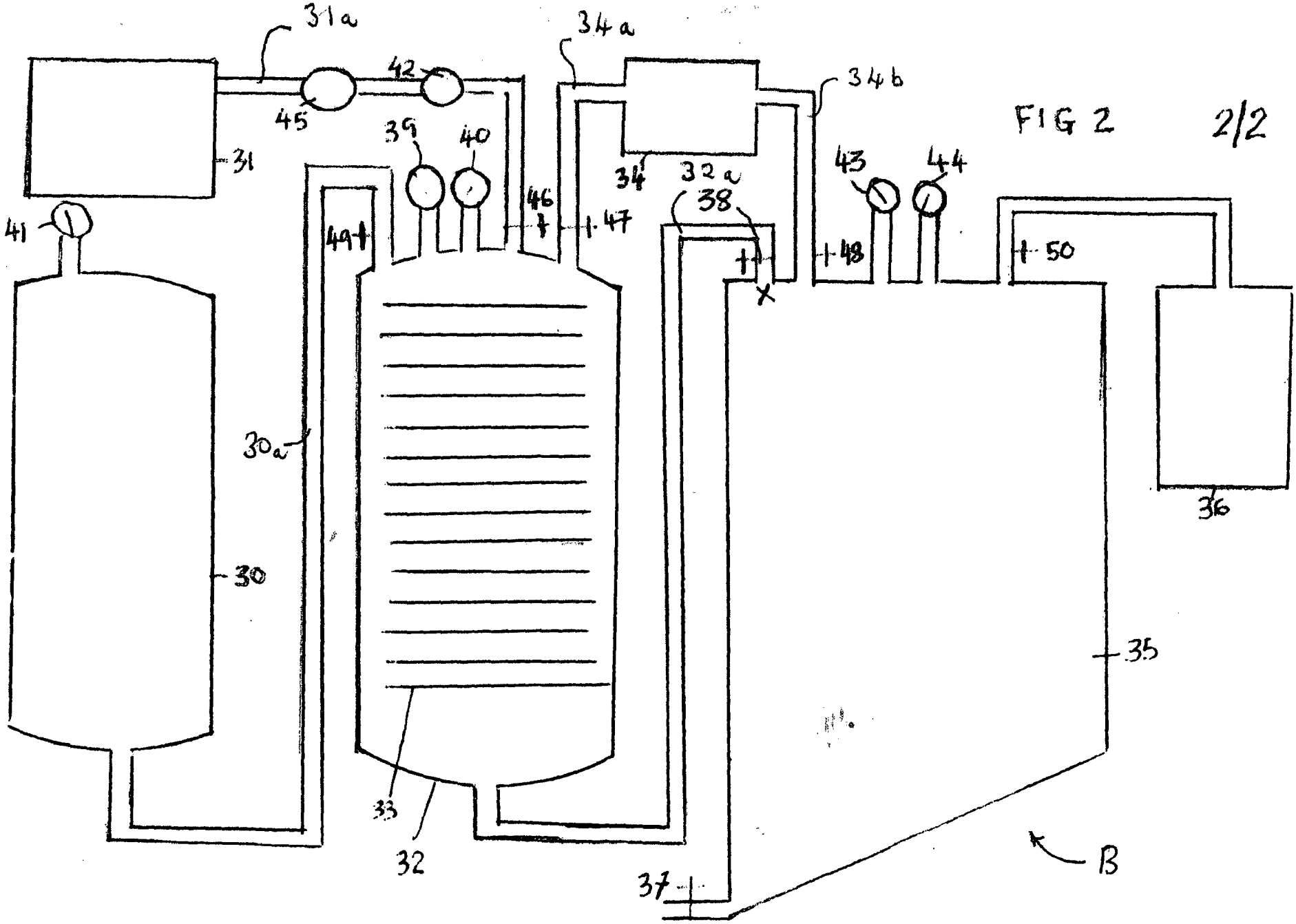
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FIG 2

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IMPROVEMENTS IN OR RELATING TO DECONTAMINATION

This invention relates to improvements in or relating to decontamination and is more particularly concerned with an antimicrobial method of treatment of articles, items or liquids and apparatus for implementing the method.

The present invention is concerned with the reduction, destruction, inhibition or control of all types of microbial populations on articles, items or liquids, most particularly single cell organisms such as bacteria, yeasts and moulds.

Microbial populations, such as populations of yeasts, moulds and bacteria are a recurring problem in many fields. For example, in healthcare, such populations may lead to serious infections. Consequently, and inconveniently, equipment and garments for use in healthcare are required to be treated to reduce the population of microorganisms, to seemingly as low a level as possible.

Microbial populations present in the processing and storage of food products may render the food unsuitable or unsafe for consumption; yeasts, moulds and bacteria on the food products need to be reduced to seemingly as low a level as possible, to prevent or reduce the possibility of the food becoming spoiled, more particularly whilst in storage.

Many antimicrobial processes are known in the art:-

For example, chemical based antimicrobial treatments are available in which antimicrobial and bactericidal agents are used to kill microorganisms. However, disadvantageously, such chemical based treatments may be unsuitable for use in some applications, particularly with foodstuffs, as the antimicrobial chemicals themselves may be unsuitable for consumption. Additionally, such chemical treatments may simply spoil the product.

Antimicrobial process involving techniques of irradiation, for example ultraviolet radiation can be used. However, again disadvantageously,there is a danger of damage to the product itself particularly where the product is food having a distinctive colour and flavour vulnerable to ionising radiation.

Sterilisation or pasteurisation antimicrobial processes can be used in which articles or food are exposed to elevated temperatures and in sterlisation, increased pressure. However,

disadvantageously, such processes tend to be energy intensive and are only suitable for articles which can withstand the high temperatures involved.

In the juicing industry, the traditional heat pasteurisation destroys some of the heat sensitive nutrients such as bioflavonoids and vitamin C of fruits and vegetables. For example, fresh orange juice contains beneficial antioxidant polyphenols and digestive enzymes which the pasteurisation process destroys. In the milk industry, pasteurisation destroys enzymes e.g Lipase needed to complete digestion of fats and it destroys all its phosphatase (which is essential for the absorption of calcium). Pasteurised milk loses 10 percent of its vitamin B1 and 20 percent of its vitamin C in the pasteurisation process. In the brewing industry, beers and wine with less than 14 percent alcohol content are normally pasteurised and their taste and flavours are affected after the process. Thus, more particularly with the increasing popularity of craft beers ,brewers are actively seeking other ways to increase the shelf life of the product without using heat pasteurisation.

Thus, the Applicant believes there is a need for an antimicrobial method of treatment which can be used to reduce populations of microorganisms to as low a level as possible without damaging e.g. the delicate nutrients and volatiles in food and in pharmaceutical industries. In particular, it is believed in such a method of treatment that the use of high temperatures should be avoided.

It is an object of the present invention to provide an antimicrobial method of treatment of articles, items or liquids which at least alleviates one or more of the aforementioned, or other, disadvantages of known methods and/or to provide apparatus for implementing such a method and/or to provide and antimicrobial method of treatment of articles, items or liquids which is improved in at least some respect and/or apparatus for implementing such an improved method.

According to a first aspect of the present invention there is provided an antimicrobial decontamination method of treatment of an article, item or liquid comprising:-

a) Placing the article, item or liquid to be treated in a pressure vessel ,
b) Introducing a gas into the vessel to increase the pressure in the vessel around or near the article, item or liquid to expose microorganisms present in contact with the article, item or liquid to the pressurising gas such that a proportion of the gas diffuses into the microorganisms through pores present in microorganisms,
c) Releasing the pressure in the vessel sufficiently quickly to kill the microorganisms or at least inhibit the microorganisms from reproducing.

Advantageously, releasing the pressure sufficiently quickly in this manner should lead to rupture of

the cell walls of the microorganisms in turn leading to them being killed or inhibited from reproducing.

Thus, by this first aspect of the present invention, populations of microorganisms can be reduced, controlled, inhibited from growing, or substantially destroyed, by exposing them to increased pressure and then releasing the pressure sufficiently quickly.

By this first aspect of the present invention, when the microorganisms are exposed to gas at high pressure, a proportion of the gas diffuses into the microorganisms through the pores in the surface of the microorganisms through which oxygen and carbon dioxide normally diffuse. When the pressure is released suddenly, the gas expands out of the pores at a rate which is greater than that which the pores can withstand, leading to rupturing in the cell wall of the microorganisms. This can result in loss of cytoplasm from the cell. If the damage is great enough, the microorganisms may be killed or at least inhibited from reproducing.

According to a second aspect of the present invention there is provided an antimicrobial decontamination method of treatment of an article, item or liquid comprising:-

a) Placing the article, item or liquid to be treated in a pressure vessel ,
b) reducing the pressure in the vessel around or near the article, item or liquid sufficiently quickly to to substantially evaporate or flash boil at least a layer of moisture on the surface on the article, item or liquid containing microorganisms, leading to a reduction in temperature and thereby killing the microorganisms or at least inhibiting the microorganisms from reproducing.

By this second aspect of the present invention, populations of microorganisms can be reduced, controlled, inhibited from growing or substantially destroyed by reducing the pressure around them quickly. Microorganisms normally exist in a thin layer of moisture on the surface of articles. If the pressure is reduced quickly, this moisture can be substantially evaporated or flash boiled, leading to a local and rapid reduction in temperature, by about as much as 10 – 20 degrees C. The resulting cold shock to the microorganisms should kill them or at least inhibit them from reproducing.

Water is one of the most important factors in bacterial growth and reproduction. Bacteria need water to dissolve the food they use for energy and growth. Rapid evaporation of water from the surface of articles and from the surface of bacteria reduces the water activity (aw) of those surfaces, hindering bacterial growth and multiplication.

Embodiments of methods and apparatus in accordance with the present invention should be particularly effective at controlling, reducing, substantially destroying, or preventing growth of populations of microorganisms which are located at an interface between a gas which is placed under pressure and a liquid or between a gas which is placed under pressure and a rigid surface of an item or article to be decontaminated. Such microorganisms are directly exposed to gas under pressure, whereby the effects of the present invention are particularly marked. This applies to microorganisms which are located on external surfaces and on internal surfaces, for example microorganisms located within porous structures.

Most preferably, during the decontamination process all ambient air is excluded. When oxygen in ambient air is compressed aerobic bacteria may be encouraged to multiply rapidly during the decontamination process. Oxygen also impairs and oxidises bioflavonoids and vitamin C. Carbon dioxide tends to form Carbonic acid with any water present in the article/item or liquid to be treated. In food products Carbonic acid would deactivate some of the enzymes.

The Applicant has realised that during the process of cold pasteurisation, the vital enzymes in raw foods are preserved along with aroma and bioflavonoids. Enzymes are proteins with fragile structures and have vital functions in our bodies. Enzymes are denatured when heated above 46.7 degrees Celsius. Traditional pasteurisation at 72 degrees Celsius denatures the enzymes. Over 90 per cent of western diet is hot pasteurised and has denatured enzymes, offering few benefits to our bodies. Raw foods are enzyme rich and consuming them decreases the burden on the body to produce its own enzymes.

Depending on the shelf life of a food product required, the level of enzyme activity during storage can be controlled by increasing or decreasing the pressure of the gas infused into the food product during cold pasteurisation, At higher treatment pressures in the reactor (pressure vessel), the enzyme activity of the food product is lowered.

Bacteria range in size from 0.2 to 2 microns in width or diameter and from 1 to 10 microns in length for the non spherical species. Viruses are 0.004 to 0.1 microns in size. Mold range 3 to 12 microns and mold spores range from 10 to 30 microns. Considering how small these various pathogens are, it is believed necessary or advantageous to employ a gas that has a very small molecule to infuse rapidly into these pathogens.

Preferably, the pressuring gas introduced into the pressure vessel to infuse the product is Helium or

the like (e.g. or another inert gas) which has, advantageously, a very small molecule.

Although the atomic number of Hydrogen is 1 and the atomic number of Helium is 2, a Helium atom is smaller than a Hydrogen atom. The radius of a Helium atom is 31 pm (picometer) and the diameter is 62 pm, whereas a Hydrogen atom has a radius of 53 pm and a diameter of 106 pm. The rate of diffusion of Helium is 45 times faster than Hydrogen.

Hydrogen could be used as the pressurising gas but because it becomes explosive with Oxygen it could pose a real danger, and should only be used with stringent safety precautions in place.

In an alternative embodiment of the present invention, a mixture of Helium and Nitrogen can be used in various ratios ranging from 10 to 30 percent of Helium to 70 to 90 percent of Nitrogen. The size of Nitrogen molecule is 155 pm. The two gases do not mix readily when they are together in the pressure reactor (vessel) because of their density differences.

The density of Helium is 0.1786 Kg per cubic metre at STP and Nitrogen is 1.2506Kg per cubic meter at STP. The Nitrogen helps to maintain the pressure in the pressure vessel, allowing the Helium to diffuse into the pathogen cells.

However, it is to be noted that any mixture of other suitable gases could be used e.g Hydrogen and Nitrogen, with appropriate safety precautions employed.

The Applicant has conducted early trials with filtered air to decontaminate food and non food articles and, importantly, had success when he used dry and oxygen free air (at higher pressures of over 10 bar – or thereabout). However, the incubation time with air was longer. Using gases with smaller sized molecules helped to use lower pressures and shorter incubation times. The captial costs of high pressure vessels and the subsequent higher energy costs has to be balanced against lower pressure systems using a gas like helium.

Accordingly, further according to the present invention there is provided an antimicrobial decontamination method of treatment comprising the steps of:

a) placing an article, item or liquid to be treated in a pressure vessel
b) exposing said, item or liquid to Nitrogen to remove all traces of atmospheric gases;
c) exposing the article, item or liquid in the pressure vessel to increased pressure with Helium, for a predetermined time, and
d) releasing the pressure in the vessel sufficiently quickly to kill or at least inhibit

reproduction of microorganisms present on or in contact with the article, item or liquid.

The Helium and Nitrogen may be vented to an expansion vessel, from where these gases may be led away to be compressed and reused.

Any water vapour emergent from the product may condense out when the gas mixture is compressed for the next cycle.

The Helium and Nitrogen mixture does not need to be separated out into their separate identities before reusing again for the next cycle. However, the Nitrogen used to flush air out of the reactor (pressure vessel), builds up changing the original ratio of Helium to Nitrogen. A Nitrogen meter may be employed to sense the additional Nitrogen in the system and used to divert some of the Helium / Nitrogen mixture to a pressure swing absorption unit which removes the excess Nitrogen to storage.

Embodiments of method and apparatus of the present invention may be used to treat a wide range of articles,items or liquids.

The article may comprise any solid article which needs to be treated to control the population of microorganisms. It may comprise an article for use in healthcare, animal care, laboratory work, horticulture or food processing, for example.

The articles, items or liquids may comprise natural products or may be man- made.The articles or items may comprise food products such as fruit, vegetables (either whole or cut) salad, meat, cereals, cereal products such as bread, biscuits or cake, oil, products such as butter, eggs fish, cheese (particularly grated cheese), sweets such as chocolate, seeds and any nuts such as almonds or brazil nuts. The foodstuff may comprise prepared food, for example guacamole, processed food or ingredients.

The articles, items or liquids may comprise medicines that are heat sensitive.

Embodiments of the present invention may be suitable for the treatment of liquids and similar materials, such as gums, oils, resins, beers, wines and the like.

The articles may comprise packaging for food, either independently of the food or with the food in place. For example, it may comprise a bag, box, carton, container,

wrapping or the like.

The articles may comprise any suitable material, for example of plastics, metal, composite material, wood, porcelain, ceramic, glass, fabrics such as cloth, yarn or fibres. The article may be in the form of a finished article or in the form of a raw material.

Further according to the present invention there is provided apparatus suitable or adapted for carrying out the antimicrobial decontamination method of treatment as described in any of the foregoing statements of invention related in this specification.

Further according to the first aspect of the present invention there is provided apparatus for carrying out a microbial decontamination method of treatment of an article, item or liquid, said apparatus comprising a pressure vessel for containing said article, item or liquid, in use,and pressurising means for increasing the pressure in the pressurising vessel by the introduction of a pressurising gas within said vessel and pressure release means for releasing the pressure in the pressurising vessel sufficiently quickly to kill or at least inhibit reproduction of microorganisms on the article, item or liquid.

In said apparatus as defined in the immediately preceding paragraph the pressure vessel may be of of any suitable design. In general, the internal size and configuration of the pressure vessel will depend upon the shape and size of articles, items or amount of liquid to be treated. The pressure vessel may be made of any suitable material capable of preventing Helium (or other pressurizing gas that may be used) from leaking from the vessel under pressure, for example metal such as austenitic stainless steels.

Preferably, the pressure vessel has a sealable entry means. The sealable entry means may be opened to allow articles to be placed in the pressure vessel, and subsequently sealingly closed so that the pressure in the vessel can be decreased at first to evacuate atmospheric gases and then filled with Helium (other other suitable gas).

The pressure vessel should be able to withstand the pressure to which the articles, items or liquids are to be submitted, which is discussed further below. Typically, the pressure vessel should, preferably, be able to withstand a pressure which is greater than the working pressure by a normal factor of safety. Preferably, the pressure vessel is provided with a pressure gauge to indicate the pressure within the pressure vessel. Preferably, the pressure vessel has a vacuum gauge to indicate the evacuation of atmospheric gases. For treatment of liquid articles such as juices, it may

have an inlet connection to the juice storage. The vessel may also have a connection to a reservoir of pressurized Helium or the like. For Liquids, the high pressure vessel may have a connection at the bottom of the vessel that would convey the pressurized liquid to second vessel, being an expansion vessel. In the expansion vessel, it is envisaged that the conveyed liquid under high pressure would be allowed to escape through a control valve to a low pressure.

In the present specification, all pressures are quoted as gauge pressures except where Indicated; examples are given using Helium but this applies to Helium/Nitrogen mixture and any other suitable gas or gases employed.

The pressure to which articles, items or liquids are submitted is preferably in excess of about 400kPa (about 4 bar) and more preferably greater than about 600kPa (6 bar) and preferably greater than 1000kPa. It is generally preferred to operate at at least about 600kPa and preferably at least about 1000kPa. The upper limit is determined by practical factors, such as the cost of pressure vessels. Suitably, the upper limit is approximately 5000kPa, preferably not more than about 2000kPa.

Advantageously. the applicant has realised that higher the pressure in the pressure vessel, the less is the incubation time required for the Helium (other gas) to infuse into microorganisms.

Any suitable means may be selected for applying pressure in the pressure vessel. For example, the pressure vessel may be connected to a source of pressurised Helium, such as via a pump.There may be a reservoir of pressurised Helium which may be continuously or periodically be fed by a pump, so that the vessel can be repressurised a number of times in succession. A plurality of different pressure vessels may be connected to a single pump or reservoir.

The article, item or liquid may remain under pressure for any suitable period of time. In practice, it is found that the time required to have an effect on bacteria can be very short depending on the pressure in the vessel. Normally being of duration of less than about 20 seconds.

A valve may be provided to regulate the supply of pressurising Helium or other gas to the pressure vessel.

The article may be treated at any suitable temperature. For example from 4 to 6 degrees celsius for food articles and for non food articles at ambient temperatures.

According to the present invention, the pressure is released quickly. This means, typically, that there may be a pressure drop of at least about 600 kPa, preferably at about 800 kPa and most preferably at least about 1000 kPa within a period of at least about one second, more preferably at least about 0.5 seconds. Any suitable means may be provided for releasing the pressure in the pressure vessel, such as a valve. Several release valves may be employed simultaneously to drop the pressure into an expansion vessel.The flow area of the passage opened to release the pressure, compared to the volume under pressure should be selected in order to obtain a sufficiently fast release of the pressure.

For example, for the pressure vessel of volume of approximately 1000 cubic cm, a nozzle diameter of approximately 50 mm is found to be sufficient.

The present invention finds particular application in antimicrobial treatment of foodstuffs, particularly in order to improve their shelf life without any detrimental change in nutritional properties, flavour and taste. The Applicant believes, advantageously, that the physiology of the foodstuff, for example, the presence of natural enzymes, is not substantially altered by the processes of the present invention.

Further according to the second aspect of the present invention there is provided apparatus for carrying out a microbial decontamination method of treatment of an article, item or liquid, said apparatus comprising a pressure vessel for containing said article, item or liquid, in use ,and pressure reducing means for reducing the pressure in the pressurising vessel sufficiently quickly to kill or at least inhibit reproduction of microorganisms on the article, item or liquid.

Further advantages of the present invention will be apparent from the following description and drawings.

Embodiments of an antimicrobial decontamination method or treatment of an article, item or liquid and apparatus for implementing the method all in accordance with the present invention will now be described, by way of example only, with reference to the accompanying schematic drawings, in which:-

FIGURE 1 shows apparatus to apply antimicrobial treatment to solid articles or items of non-food or food product, for example, fresh chicken portions, in order to extend their shelf life.

FIGURE 2 shows apparatus to apply antimicrobial treatment to a liquid of non-food or food

product, for example, fresh orange juice, in order to extend the shelf life of the liquid.

Apparatus A shown in FIGURE 1 comprises a source of compressed Helium gas in a reservoir 10 which is connected by pipework 10a and via an inlet (isolating) valve 17 to a pressure vessel 12. Items to be treated – not shown - e.g raw chicken portions are placed in trays in a rack (not shown) in the pressure vessel 12, through door 13 of vessel 12. The door 13 is then sealingly closed. An isolating valve 16, connected in pipework 11a from vacuum pump 11, is opened to evacuate the pressure vessel 12 of all atmospheric air.

When a vacuum gauge 15 operatively connected to vessel 12 indicates that the correct level of vacuum has been reached, isolating valve 16 is closed. The isolating valve 17 from the Helium reservoir 10 is opened to feed Helium gas.to the pressure vessel 12 until the desired pressure is achieved as indicated by pressure gauge 14. The isolating valve 17 is then closed to prevent ingress of further helium gas. The items (chicken portions) in the pressure vessel 12 are left for a predetermined period of time. In order to control the population of bacteria the period of time need only be about 30 seconds

After this period of time has elapsed, valve 18 in pipework 20a is opened so that the compressed helium gas is released to expansion vessel 20 through pipework 20a. The expansion vessel 20 has a large volume compared to that of pressure vessel 12, being approximately ten times the volume of the pressure vessel 12. The dimensions of the gas flow channel in the valve18 is selected so that very rapid release of gas occurs, preferably allowing the pressure to reduce from.about 1000kPa to about minus100 kPa in less than 0.5 seconds. This rapid release is made possible by having a vacuum in the expansion vessel 20 since it is connected to a second vacuum pump (not shown) via isolating valve 24 prior to the valve 18 being opened.The isolating valve 24 remains closed during the release of Helium from pressure vessel 12. The Helium is released via a further isolating valve 23 from the expansion vessel 20 to a Helium gas compressor (not shown) which compresses the gas ready for next treatment cycle.

The antimicrobial decontamination method of treatment may be repeated on the items if thought necessary.

After the treatment is completed the residual Helium (or other gas) is removed from the pressure vessel 12 and expansion vessel 20 by the Helium compressor through the valve 23.

The isolating valves 18 and 23 are closed and isolating valve 25 is opened to bring filtered air into

the pressure vessel 12 or any other gas such as Nitrogen to protect the product from Oxygen for reasons as previously stated in this specification.

A further isolating valve 25 is connected via pipework 26a to a filter assembly 26, which consist of very fine pore filter pads for filtering out particulate material and microorganisms such as bacteria, moulds and yeasts.

The sealable access door 13 is opened and the treated articles unloaded for packaging.

The rapid reduction in pressure should have three effects. Firstly, gas which has permeated through the pores on the surface of microorganisms expands rapidly, leading to rupture of the pores and the cell wall of the microorganisms, thereby killing or disabling them.Further, the drop in pressure to below atmospheric pressure should lead to the very rapid evaporation of a surface layer of moisture on the item or article. Microorganisms living within this layer of moisture will be subjected to a very rapid temperature drop as the moisture is evaporated. This should expose them to a cold shock, which may be enough to kill them or which should at least prevent them from reproducing.

This evaporation further reduces the availability of free water to the microorganisms for their growth and reproduction. Pathogenetic bacteria do not grow well or produce toxins below water activity of 0.85aw (aw = water activity).

FIGURE 2 shows an apparatus B according to a second embodiment of the invention for decontamination treatment of liquids , for example orange juice.

A pressure vessel 32 is provided which is a tall tower inside which are stacked sieves 33, one above another with a small gap between each sieve.The sieves 33 can be made of any suitable material e.g stainless steel, food grade. The pressure vessel 32 is connected by pipework 34a via an isolating valve 47 to a vacuum pump 34. Similarly, an expansion vessel 35 is connected to the vacuum pump 34 by pipework 34b via isolating valve 48.

When both vessels 32 and 35 are under vacuum , as indicated by vacuum gauges 40 and 44, the valves 47 and 48 are closed. An isolating valve 49 in pipework 30a connecting the pressure vessel 32 to a Helium storage reservoir 30, is opened to allow Helium to fill the pressure vessel to the desired pressure. Once the desired pressure is attained, as indicated by a pressure gauge 39, isolating valve 46 is opened and a high pressure pump 45 in pipework 31a is started to pump deaerated orange juice from a reservoir 31. The juice from reservoir 31 is pumped through a non

return valve 42 in pipework 31a to the pressure vessel 32. The juice in the pressure vessel 32, falls through the sieves 33, exposing thin surfaces of the juice along with the bacteria to the high pressure Helium. The Helium penetrates the exposed bacteria effectively.

After a predetermined time, an isolating valve 38 in pipework 32a is opened to allow the juice under pressure to explode into the expansion vessel 35 which was under a vacuum. Simultaneously, isolating valve 50 is opened for the Helium to be removed in the expansion vessel 35 by way of a compressor 36. The Helium is compressed and stored for the next cycle. The treated juice collects at the bottom of the expansion vessel 35. The juice can then be removed through via isolating valve 37 at the bottom of the expansion vessel 35, to be packed. The rate of pumping juice from reservoir 31 to pressure vessel 32 is matched with the outflow of the juice from pressure vessel 32 to expansion vessel 35.

It is important for every product to be cold pasteurised; a sample of the product has to be subjected to empirical tests to establish correct pressure of gas and infusion time required with the gas in the pressure vessel to kill all microorganisms. These results would form the benchmark to process the product.

The process for the microbiological decontamination of solid articles or items can be automated to a continuous line process. This can be achieved by the conveyor belts (not shown) feeding several high pressure vessels which release the treated articles or items at intervals of times to give a continuous line.

It is to be understood that the scope of the present invention is not to be unduly limited by the particular choice of terminology and that a specific term may be replaced or supplemented by an equivalent or generic term.' Having' may be replaced by 'comprising' or 'including'; liquid' may be replaced or supplemented by fluid'. Further it is to be understood that individual features, method or functions relating to the microbiological decontamination treatment or apparatus might be patentably inventive. The singular may include the plural and vice versa.

Additionally, any range mentioned herein for any parameter or variable shall be taken to include a disclosure of any derivable sub-range within that range or of any particular value of the variable or parameter arranged within, or at an end of, the range or sub-range.

In summary, in important embodiments of the present invention, in order to provide an antimicrobial method of treatment or apparatus for dealing with bacteria, yeast or moulds, an article

to be decontaminated is placed in a pressure vessel which is supplied with compressed gas. Once the pressure in the vessel has reached about 1000kPa, the supply is switched off and the pressure is reduced suddenly by connecting the pressure vessel to a vacuum reservoir which leads to a drop of pressure in the pressure vessel of about 1000 kPa in about 0.5 seconds. Gas which has been absorbed by microorganisms expands suddenly and disrupts their cell walls, leading to destruction or disablement of the microorganisms. A microscopic layer of liquid on the surface of article in the pressure vessel is flash boiled leading to a temperature shock which also damages any microorganisms which have survived the pressure drop.

27. Apparatus as claimed in 25 or 26 in which a pressure gauge or pressure indication means is operatively connected to the pressure vessel, in use, to indicate the pressure within said pressure vessel.

28. Apparatus as claimed in any one of claims 25 to 27 in which a vacuum gauge or vacuum indication means is operatively connected to the pressure vessel to indicate the level of vacuum.

29. Apparatus as claimecd in any one of claims 25 to 28 in which the pressure vessel has an inlet connection, in use, to a liquid storage source, said liquid to be decontaminated.

30. Apparatus as claimed in any one of claims 25 to 29 in which the pressure vessel has a connection, in use, to a reservoir of pressurizing gas.

31. Apparatus as claimed in any one of claims 25 to 30 in which the pressure vessel is connected, in use, to an expansion vessel.

32. Apparatus as claimed in claim 31 in which the expansion vessel has a volume about ten times that of the pressure vessel.

33.Apparatus as claimed in claim 31 or claim 32 having a gas flow pipework or channel from the pressure vessel to the expansion vessel, the dimensions of the pipework/channel being such that , in use, pressure in the pressure vessel can be reduced from about 1000kPa (+/- 50kPa) to about minus 100kPa (+/- 20 kPa) in less thst about .5 (+/- .1) seconds.

34. Apparatus as claimed any one of claims 15 to 33 in which the pressure vessel is connected to pressurising gas, in use, by pump means

35. Apparatus as claimed in any one of claims 31 to 34 in which the expansion vessel is connected to second pump means to create a vacuum in the expansion vessel.

36. Apparatus as claimed in any one of claims 15 to 35 which there is a reservoir of pressurising gas which can be continuously or periodically be fed by pump means, so that the vessel can be repressurised a number of times in succession.

37. Apparatus as claimed having a plurality of pressure vessels.

38. Apparatus as claimed in claim 37 in which the pressure vessels are are connected to a single pump or reservoir.

39. Apparatus as claimed in any one of claims 15 to 38 in which valve means is provided to regulate the supply of pressurising gas to the pressure vessel or vessels.

40. Apparatus as claimed in any one claims 15 to 39 having release valve means provided for releasing the pressure in the pressure vessel, such as a valve.

41. Apparatus as claimed in claim 40 in which the release valve means comprises a plurality of release valves that can be employed simultaneously to drop the pressure into a, or the, expansion vessel.

42. Apparatus as claimed in any one of claims 15 to 28 in which the pressure vessel is of volume of approximately 1000 cubic cm +/- 500 cc with a nozzle diameter of approximately 50 mm +/- 5mm.

43. Apparatus as claimed in any one of claims 15 to 42 having a Nitrogen meter. .

44. Apparatus suitable or adapted for carrying out the antimicrobial decontamination method of treatment as claimed in any one of claims 1 to 24.

45. Apparatus for carrying out a microbial decontamination method of treatment of an article, item or lquid, said apparatus comprising a pressure vessel for ccontaining said article, item or liquid, in use, and pressurising reducing means for reducing the pressure in the pressurising vessel sufficiently quickly to kill or at least inhibit reproduction of microorganisms on the article, item or liquid.

46. Apparatus or method substantially as herein described or illustrated with reference to the FIGURES of the drawings or having any feature or combination of features derivable from the description and/or FIGURES of the drawings.

47. A method as claimed in claim 2 in which water activity is lowered around the microorganisms during pressure reduction.

48.A method as claimed in claim in claim 1 in which the article, item or liquid is food, treated in dry air in the absence of oxygen and carbon dioxide, or non-food treated in the abscence of oxygen, at a pressure of about 1000kPa (+/- 50 kPa).

.CLAIMS

1.An antimicrobial decontamination method of treatment of an aticle, item or liquid comprising:-

a) Placing the article, item or liquid to be treated in a pressure vessel ,

b) Introducing a gas into the vessel to increase the pressure in the vessel around or near the article, item or liquid to expose microorganisms present in contact with the article, item or liquid to the pressurising gas such that a proportion of the gas diffuses into the microorganisms through pores present in microorganisms,

c) Releasing the pressure in the vessel sufficiently quickly to kill the microorganisms or at least inhibit the microorganisms from reproducing.

..

2. An antimicrobial decontamination method of treatment of an aticle, item or liquid comprising:-

a) Placing the article, item or liquid to be treated in a pressure vessel ,

b) reducing the pressure in the vessel around or near the article, item or liquid sufficiently quickly to to substantially evaporate or flash boil at least a layer of moisture on the surface on the article, item or liquid containing microorganisms, leading to a reduction in temperature and thereby killing the microorganisms or at least inhibiting the microorganisms from reproducing.

3. A method as claimed in claim 1 or claim 2 in which ambient air is excluded during treatment of the article, item or liquid by evacuating air in the pressure vessel.

4. A method as claimed in claim 3 in which air is evacuated from the pressure vessel to a selected level of vacuum.

5. A method as claimed in claim 1 or in claim 3 or claim 4 when dependent from claim 1 in which the gas is introduced into the pressure vessel to a selected pressure level.

4. A method as claimed in claim1 or any claim when dependent on claim 1 in which the gas is an inert gas.

5. A method as claimed in claim 4 in which the gas is Helium.

6. A method as claimed in claim 4 in which the gas is Hydrogen.

7. A method as claimed in claim 5 or claim 6 including introducing a second pressurising gas into the vessel in addition to said first mentioned gas.

8. A method as claimed in claim 7 in which said second gas is Nitrogen.

9. A method as claimed in claim 8 in which the first and second gasses comprise a mixture of Helium and Nitrogen in the ratio ranging from about 10 to 30 percent (+/- 5 percent) of Helium to about 70 to 90 percent (+/- 5 pecent) of Nitrogen. .

10. A method as claimed in claim 1 or any claim dependent therefrom in which the pressure to which articles, items or liquids are submitted is in excess of about 400kPa (about 4 bar) +/- 20 kPa.

11. A method as claimed in claim 10 in which said pressure is greater than about 600kPa (6 bar) +/- 20kPa.

12. A method as claimed in claim 11 in which the pressure is greater 1000kPa +/- 50 kPa

13. A method as claimed in claim 12 in which the pressure is less than about 5000kPa +/-50kPa.

14. A method as claimed in claim 13 in which the pressure is less than about 2000kPa +/- 50kPa.

15. A method as claimed in claim 1 or any claim dependent therefrom in which the article, item or liquid is subjected to the pressurising gas for about 20 seconds +/-10 seconds or less.

17. A method as claimed in any one of the preceding claims in which the article, item or liquid is a food substance treated for a time period of about 4 to 6 seconds +/- 1 second.

18. A method as claimed in any one of claims 1 to 15 in which the article, item or liquid is a non-food substance treated at ambient temperature.

19.A method as claimed in any one of the preceding claims in which the pressure is released or reduced within a period of at less than about 1 second (+/- .2 seconds).

20. A method as claimed n claim 19 in which the pressure is released or reduced within a period of at less than about 0.5 seconds (+/- .2 seconds).

.. 21. An antimicrobial decontamination method of treatment comprising the steps of:

a) placing an article, item or liquid to be treated in a pressure vessel
b) exposing said, item or liquid to Nitrogen to remove all traces of atmospheric gases;
c) exposing the article, item or liquid in the pressure vessel to increased pressure with Helium, for a predetermined time, and
d) releasing the pressure in the vessel sufficiently quickly to kill or at least inhibit reporoduction of microorganisms present on or in contact with the article, item or liquid.

22.A method as claimed in claim 21 in which the Helium and Nitrogen are vented to an expansion vessel.

23. A method as claimed in claim 22 in which any water vapour emergent from the method of treatment can condense out on compression of the helium/nitrogen gas mixture for another cycle of treatment.

24. A method as claimed in any one of claims 21 to 23 in which any excess nitrogen built up during decontamination is removed.

25. Apparatus for carrying out a microbial decontamination method of treatment of an article, item or liquid, said apparatus comprising a pressure vessel for ccontaining said article, item or liquid, in use, and pressurising means for increasing the pressure in the pressurising vessel by the introduction of a pressurising gas within said vessel and pressure release means for releasing the pressure in the pressurising vessel sufficiently quickly to kill or at least inhibit reproduction of microorganisms on the article, item or liquid.

26. Apparatus as claimed in claim 25 in which the pressure vessel has a sealable entry means. .

Intellectual Property Office

Application No:	GB1818067.9	**Examiner:**	Helen Yard
Claims searched:	1-26	**Date of search:**	11 September 2019

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-26	US 5288462 A (CARTER) See especially column 3 lines 35-57
X	1-26	US 1728333 A (CROWTHER) See whole document
X	1-26	EP 0040887 A (SCHMIDT) See especially page 2 lines 23-37 and claims
X	1-26	US 7527734 B1 (SHEPHERD) See especially column 4 lines 27-35 and claims
X	1-26	US 1711097 A (KRATZER) See whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A23L; A61L

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
A61L	0002/02	01/01/2006
A23L	0003/015	01/01/2006