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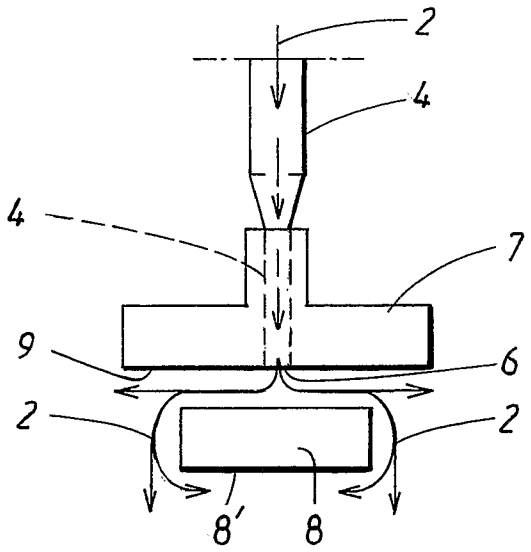

FIG. 2

(57) Abstract: The invention concerns a device (1) for lifting and handling of objects (8), such as food products, said device (1) comprising an object gripping member (7) having a lower surface (9) that is intended to be positioned above an object (8) to be handled when the gripping member (7) is set in an operating position, said gripping member (7) further having a main gas outlet (6) arranged in association with said surface (9), and a gas supply system (3, 4) for supplying a flow of gas (2) to the main gas outlet (6) during operation of the device (1), wherein the lower surface (9) and the main gas outlet (6) are arranged so as to allow the gas to flow between the surface (9) and the object (8) when the gripping member (7) is set in its operating position such that an object lifting force is induced. The invention is characterized in that the gas supply system (3, 4) is capable of supplying a gas that exhibits antimicrobial properties. The invention also concerns a method for lifting and handling of objects.

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Device and method for lifting and handling of objects

TECHNICAL FIELD

This invention relates to a device for lifting and handling of objects. In particular, the invention relates to a Bernoulli-type lifting device for handling of food products.

BACKGROUND ART

Industrial handling of foodstuff involves a number of technically challenging operations such as handling and processing of sensitive food products, individual handling of food products that vary considerably in size, shape etc., meeting strict requirements of hygienic handling, decontamination treatments of various types of food products, etc.

Conventionally, food products are to a great extent handled manually. Automated handling of foodstuff is an important issue for the food industry to achieve improved product quality, reductions in unit production costs, better hygiene, more repeatable processing, and reduced labour costs.

Various techniques for gripping items have been developed over the years. One example is mechanical grippers that clamp or pinch the material between gripper fingers and another is vacuum grippers using suction cups to grip items. Such grippers are, however, not suitable for all types of food products. Further, vacuum grippers involve the risk of malfunctioning due to clogging. Techniques based on e.g. freezing and electrostatic forces have also been presented. A general drawback of grippers that come in direct contact with the food products, including the hands of humans, is the risk of bacterial contamination or cross product contamination.

An interesting technique for automatic handling of foodstuff is the so-called Bernoulli gripper. Such grippers make use of the Bernoulli principle saying, in short, that the static pressure of a fluid decreases with increasing flow velocity. In a conventional Bernoulli gripper, air is forced to flow at a high speed between a lower surface of the gripper and an upper side of the object to be lifted. This way a difference in static pressure below and above the object is created which results in a lifting force used to lift the object, similar to the lifting force created by an aircraft wing. This lifting technique has been known for many years in the semi-conductor industry for handling rigid silicone wafers and circuit boards, see e.g. US 2005/145180, and US 2005/110291.

An advantageous feature of Bernoulli grippers is that it is a non-contact lifting technique, i.e. the gripper does not have to come in direct contact with the object lifted since the lifting force reaches an equilibrium with the opposed air jet force at a distance from the gripper surface. Thus, it is a sensitive lifting technique reducing risk for bruising. In addition, the risk of contaminating objects is reduced. By providing a robot with end effectors in the form of Bernoulli grippers, handling of certain food products may be automated.

Recently, this technique has been tested out on thin, sheet-like food products such as lasagne pasta, sliced salmon, cheese and ham. These tests have shown that the use of Bernoulli grippers in food industry appears to be promising. However, adaptation of conventional Bernoulli grippers to what is required for handling foodstuff is not yet fully satisfactory, e.g. with regard to the difference in handling variable food products in contrast to smooth, rigid and regularly shaped silicone wafers. Improvements and adaptations of this technique are thus desired.

DISCLOSURE OF INVENTION

An object of this invention is to provide a Bernoulli-type gripping device that exhibit improved functional properties compared to conventional gripping

devices, in particular with regard to industrial handling of food products. This object is achieved by providing a device and method as defined by the technical features contained in independent claims 1 and 12. The dependent claims contain advantageous embodiments, further developments and variants of the invention.

The invention concerns a device for lifting and handling of objects, such as food products, said device comprising an object gripping member having a lower surface that is intended to be positioned above an object to be handled when the gripping member is set in an operating position, said gripping member further having a main gas outlet arranged in association with said surface. The device further comprises a gas supply system for supplying a flow of gas to the main gas outlet during operation of the device, wherein the lower surface and the main gas outlet are arranged so as to allow the gas to flow between the surface and the object when the gripping member is set in its operating position such that an object lifting force is induced. The inventive device is characterized in that the gas supply system is capable of supplying a gas that exhibits antimicrobial properties.

In other words, the invention concerns a Bernoulli-type gripping device provided with a gas supply system that can supply a gas with decontaminating or sterilizing properties. Such a gas is capable of inactivating micro-organisms on surfaces it comes in contact with. Since the gas flows along the surface of the object during operation of the device, a device is provided that can handle or lift an object and at the same time decontaminate its surface.

Alternative decontamination methods available, such as UV-radiation and high intensity pulsed light, generally have problems with parts of the product that are "shadowed" and thus remain non-treated. That could e.g. be parts of the product that rest against the conveyor or the surface of gripper fingers. In the inventive device all surfaces are immersed in a decontaminating gas

since the gripper does not contact the object and therefore no "shadowed" areas will exist.

To combine a Bernoulli-type gripper with the use of a decontaminating gas is a particular advantage in the handling of foodstuff because it improves, simplifies and speeds up certain handling procedures considerably. For instance, a food product can e.g. be gripped by a robot, decontaminated and placed in a packaging in a single step.

Conventional, air-driven Bernoulli grippers are associated with hygienic problems as a result of the turbulence created during use. Also this problem is solved by the present invention. In contrast to such conventional air-driven grippers, turbulence becomes a positive feature when a decontaminating gas is used in that the surface decontamination, and thus the hygiene, is enhanced.

Furthermore, Bernoulli-type gripping is a very sensitive way of handling food products with no risk of bruising and it is also suitable for being automatized. The present invention thus provides a fast, hygienic and sensitive device for handling and lifting of objects, such as food products. Further, such a device has a relatively simple structure and no moving parts which make the device easy to keep clean.

Preferably, the gas supply system comprises a gas source and a main gas conduit for feeding the gas flow from the gas source to the main gas outlet. Typically, the gas source can be a gas tube or an internal gas network, but it can be any other type of gas source suitable for supplying gas to the main gas conduit.

In a preferred embodiment of the invention the device comprises a plasma generator arranged to generate plasma in the gas flow that, during operation of the device, is supplied to the main gas outlet. By generating plasma in the

gas flow, the gas will contain reactive chemical species, such as excited and ionized atoms and molecules, which species have a microbial effect.

The use, as such, of plasma generators for decontamination purposes is known from e.g. WO0074730 and US 6790410. However, plasma decontamination is traditionally performed as a separate handling step in a particular chamber adapted for this certain purpose. The inventive device allows for a more automated and efficient use of plasma generators since an object can be decontaminated and e.g. put in a package simultaneously. Further, the plasma may be transported with the gas flow over a certain distance which means that plasma generation and microbial inactivation may take place at different locations.

In a preferred variant of this embodiment the plasma generator comprises a high voltage supply capable of applying a high voltage to an electrode, said electrode being positioned in a chamber forming part of the main gas conduit mentioned above. Such a plasma generator is suitable for producing a so-called cold plasma which is suitable for the purpose of handling heat-sensitive products. A further advantage of using such a plasma generator is that the gas supply system can be operated independently of the plasma generator, which for instance means that the gas may be allowed to flow continuously through the main gas conduit whereas the plasma generator can be turned on or off depending on the need for decontamination.

In a further preferred variant of this embodiment, the gas source contains nitrogen gas. An advantage of using this gas is that it allows for generating a plasma at atmospheric pressure and at suitable temperatures, around 30-40°C. Another advantage is that the nitrogen plasma does not introduce undesired foodstuff reactions, such as lipid oxidation. A further advantage is that both the starting compound (for generating the plasma) and the end product (of re-combined plasma) is nitrogen. Further, nitrogen is not hazardous.

In another preferred embodiment of the invention the abovementioned gas source contains a gas that exhibits antimicrobial properties. Examples of such gases are ozone (O_3), hydrogen peroxide (H_2O_2) and ethanol (C_2H_5OH) vapour. Which gas or gas mixture to choose depends for instance on what type of object that is to be handled by the device. In this embodiment no plasma generator is necessary. However, the embodiments can be combined so that a plasma is induced in a gas that exhibits antimicrobial properties or so that two different gas flows, one from each embodiment, are mixed upstream of the main gas outlet.

The invention also concerns a method for lifting and handling of objects, such as food products, using a device of the above type. The inventive method is characterized in that it comprises the step of supplying a flow of gas that exhibits antimicrobial properties to the main gas outlet.

In a preferred embodiment of the method it further comprises the step of exposing the gas flow to a plasma generator so as to give the gas antimicrobial properties.

BRIEF DESCRIPTION OF DRAWINGS

In the description of the invention given below reference is made to the following figure, in which:

Figure 1 shows, in a schematic view, an overview of a preferred embodiment of the invention,

Figure 2 shows, in a schematic view, a gripping member according to the invention,

Figure 3 shows, in a sectional side view, a variant of a gas supply system according to the invention, and

Figure 4 shows, in a sectional side view, another variant of a gas supply system according to the invention.

EMBODIMENT(S) OF THE INVENTION

Figure 1 shows, in a schematic view, an overview of a first preferred embodiment of the inventive device 1 for non-contact handling and lifting of objects, such as food products. The device 1 comprises a gas source 3, a plasma generator 5, and an object gripping member 7 in the form of a so-called Bernoulli gripper. The gripping member 7 is arranged on an arm 17 of a robot 16, which robot 16 is controllable by known means. A main gas conduit 4 is arranged for feeding a gas flow 2 from the gas source 3, via the plasma generator 5, to the gripping member 7. The gripping member 7 lifts an object 8.

Figure 2 gives, schematically, a more detailed view of the object gripping member 7 in an operation position. As shown in figure 2, the gripping member 7 has a substantially flat lower surface 9 intended to be positioned above the object 8 to be handled or lifted. The main gas conduit 4 extends through the object gripping member 7 to a main gas outlet 6 in the form of an opening in the lower surface 9. The gripping member 7 has in this case a circular shape seen in a vertical direction, which means that also the lower surface 9 has a circular shape and that the gas outlet 6 is positioned in the middle, i.e. in a central region, of this circular lower surface 9.

In the described example, the gas source 3 is a gas cylinder containing nitrogen gas. As an alternative to a gas cylinder, the gas source 3 can for instance be a local gas network or another type of pressurized container.

The plasma generator 5 is a so-called cold plasma jet including a high voltage power supply 12, an electrode 13 and a grounded detail 14. The electrode is connected to the power supply 12 and is placed in a flow-through

chamber 4c forming part of the main gas conduit 4. The function and structure of such a plasma generator 5 are, per se, known for a person skilled in the art.

The gas source 3 and the main gas conduit 4 can be controlled independently of the plasma generator 5 so that the gas may be allowed to flow continuously through the main gas conduit 4 whereas the plasma generator 5 can be turned on or off depending on the need for decontamination.

The plasma produced in the generator 5 has a reasonably long lifetime so it is possible to place the generator 5 some distance away from the gripping member 7. However, because of the decay of the plasma its intensity will decrease with distance/time. Whether the plasma intensity will be sufficient at the time it reaches the gripping member 7 depends e.g. on the characteristics of the plasma generator 5, the distance between the plasma generator 5 and the gripping member 7, and the gas flow 2 rate. The material of the main gas conduit 4 downstream the plasma generator 5 has also an effect on the decay of the plasma.

As shown in figure 2, the gas outlet 6 is arranged in said lower surface 9 so that a gas flow, indicated by arrows 2, can flow between the surface 9 and the object 8 when the gripping member 7 is placed in an operating position, i.e. when the gripping member 7 and the object 8 are positioned relative each other such that the gripping member 7 is positioned above and relatively close to the object 8 that is to be handled or lifted.

The arrows 2 in figures 1 and 2 indicate how the gas flows during operation of the device 1 from the gas source 3, via the plasma generator 5, through the object gripping member 7, out through the gas outlet 6 and further between the lower surface 9 and the object 8 when the gripping member 7 is placed in its operating position. As indicated in figure 2, the gas flows partly

around the object 8 during operation of the device 1 such that the gas comes in contact also with the sides and an underside 8' of the object. This is because the gas flows in a highly turbulent manner after having passed the narrow space between the lower surface 9 of the gripping member 7 and an upper side of the object 8. In this operating position, an object lifting force is induced by a pressure difference between the upper side of the object 8 facing the surface and the opposite, lower side of the object 8. Thus, the static pressure is lower above the object 8 than below. As is well known, there is no lifting force created if the distance between the lower surface 9 and the object 8 is too long, in which case no low-pressure region is formed between the surface 9 and the object 8, or if the distance is too short, in which case the gas to a too high extent is prevented from flowing between the surface 9 and the object 8. In between these two extremes, there is a distance interval in which it is possible for the gripping member 7 to lift and handle the object 8 without coming in direct contact with it.

The plasma generator 5 has the function of generating a plasma in the gas flow 2 that, during operation of the device, is supplied to the gas outlet 6. After having passed the plasma generator 5, the gas will contain reactive chemical species, such as excited and ionized atoms and molecules. Such species have a decontaminating or sterilizing effect on microbial contaminants, i.e. the gas exhibits antimicrobial properties. This means that the gas that leaves the gas outlet 6 and flows along the surfaces of the object 7 has a decontaminating function.

In principal, a laminar gas flow between the lower surface 9 and the object 8 leads to a good lifting force, whereas a turbulent flow leads to a good decontaminating effect. To achieve a high decontaminating effect the plasma close to the product surface must continuously be renewed during gripping. Therefore the gas flow has to be suitably adjusted to the dimensions used in a particular setup. For a good convection of the plasma gas at the surface the plasma gas flow should be adjusted so that the flow becomes turbulent.

In the described example, the gas is nitrogen. Nitrogen gas is particularly suitable for this purpose since it is inert and forms no radicals, it re-forms into nitrogen gas after the plasma has decayed, it is possible to produce a cold nitrogen plasma jet at 30-40°C, and it is easily available and relatively inexpensive. Alternatively, it is possible to use other gases, such as air, oxygen, helium, argon, or mixtures thereof.

Preferably, the object gripping member 7 is arranged in an enclosed space such that the gas used for lifting and decontamination can be re-circulated, i.e. gas is led from the enclosed space to the gas source.

In certain situations, in particular when handling flat and wide objects 8, the gas flowing out from the gas outlet 6 may not be sufficient for contacting the underside 8' of the object 8. To make the device 1 capable of decontaminating the object 8 properly also in such situations, additional gas conduits, e.g. branches of the main gas conduit 4, may be used to ensure that the decontaminating gas flow 2 contacts the whole surface of the object 8.

Figure 3 shows, in a sectional side view, a variant of the inventive device 1 where the difference compared to figures 1 and 2 is that the gas supply system comprises a lower additional gas conduit 4', with a corresponding additional gas outlet 6', arranged to direct a part of the gas flow 2 in a direction towards an underside 8' of the object 8, i.e. the side of the object 8 facing away from the lower side 9 of the gripping member 7. The lower additional gas conduit 4' is movably arranged such that it can be placed in position below the object 8 when the object 8 has been lifted. The lower additional gas conduit 4' can be pivotally attached to the gripping member 7 for automatic positioning below, and away from, the object 8 to direct gas towards its down side 8'. Alternatively, the lower additional gas conduit 4' can be attached stationary within the reach of the robot arm 17, so that the robot

16 can carry the object 8 and pass it above the gas outlet 6' of the lower additional gas conduit 4'. The lower additional gas conduit 4' is connected to an upstream part of the main gas conduit 4 as to form a branch (not shown in figure 3).

Figure 4 shows, in a sectional side view, another variant of the inventive device 1 where the difference compared to figures 1 and 2 is that the gas supply system comprises two upper additional gas conduits 4", with corresponding additional gas outlets 6", arranged through and at the sides of a slightly modified gripping member 7'. In similarity with the lower additional gas conduit 4', the purpose of these upper additional gas conduits 4" is to direct a part of the gas flow 2 towards the underside 8' of the object 8, i.e. the side of the object 8 facing away from the lower side 9 of the gripping member 7, 7'.

In figure 3 the additional gas conduit 4' is arranged to direct the gas flow 2 straight towards the underside 8' of the object 8, whereas the additional gas conduits 4" in figure 4 are arranged to make the gas flow 2 to interact with the gas flow coming from the gas outlet 6 as to contact the underside 8' with the decontaminating gas 2 in a more indirect manner.

The upper additional gas conduits 4" are connected to an upstream part of the main gas conduit 4 as to form branches (not shown in figure 4). As can be seen in figure 4, the upper additional gas conduits 4" are positioned at a distance from a center point of the gripping member 7, where the gas outlet 6 is positioned, and exhibit an angle relative to a vertical direction such as to direct the gas flows at the sides of and down under the object 8. Depending on the shape of the object 8 handled the additional upper gas conduits 4" can be used to improve the lifting Bernoulli effect (working as local Bernoulli grippers). If the flow is kept laminar it will tend to "stick to" or follow the objects´ surfaces, and thus reach better for improved decontaminating effect (provided that the flow is at least partly turbulent close to the surfaces).

The lower additional gas conduit 4' and the upper additional gas conduits 4" can be used as alternatives or can be combined.

The mass flow rate in the additional gas conduits 4', 4" can generally be rather low. A higher flow rate may be required if these flows are to be used for giving rise to an additional lifting effect.

The invention is not limited by the embodiments described above but can be modified in various ways within the scope of the claims. For instance, as an alternative or complement to the plasma generator 5, it is possible to use a gas source 3 that contains a gas that exhibits antimicrobial properties, e.g. a gas selected from the following group: ozone, hydrogen peroxide and ethanol vapour.

Moreover, the inventive device 1 is useful also for handling other objects than foodstuff, such as medical equipment or other products that should be sterilized. Of course the device 1 can be used also for lifting/handling only, i.e. without supplying a gas with decontaminating properties to the gripping member 7. Either the plasma generator 5 can be turned off or, if the gas source 3 contains a decontaminating gas, use a second gas source containing a non-decontaminating gas, such as nitrogen or air.

The term main gas outlet, in contrast to the term additional gas outlet, is used to designate the gas outlet that is arranged for the purpose of creating a Bernoulli lifting force. The main gas outlet 6 may be designed in different ways depending on the application parameters, such as required gas flow rate. Further, several main gas outlets may be connected to the main gas conduit 4 and be distributed over a certain portion of the lower surface 9 of the gripping member 7.

Further, the device can be provided with e.g. a cone-shaped component positioned below the main gas outlet 6 for directing the gas flow towards the space between the gripping member 7 and the object 8 to prevent that the gas flow is directed straight towards the object 8. Such an additional component can also be used to influence the flow pattern (laminar – turbulent) of the gas flow.

CLAIMS

1. Device (1) for lifting and handling of objects (8), such as food products, said device (1) comprising
- an object gripping member (7) having a lower surface (9) that is intended to be positioned above an object (8) to be handled when the gripping member (7) is set in an operating position, said gripping member (7) further having a main gas outlet (6) arranged in association with said surface (9), and
- a gas supply system (3, 4) for supplying a flow of gas (2) to the main gas outlet (6) during operation of the device (1),
wherein the lower surface (9) and the main gas outlet (6) are arranged so as to allow the gas to flow between the surface (9) and the object (8) when the gripping member (7) is set in its operating position such that an object lifting force is induced,
characterized in
that the gas supply system (3, 4) is capable of supplying a gas that exhibits antimicrobial properties.

2. Device (1) according to claim 1,
characterized in
that the gas supply system comprises a gas source (3) and a main gas conduit (4) for feeding the gas flow (2) from the gas source (3) to the main gas outlet (6).

3. Device (1) according to claim 1 or 2,
characterized in
that the device (1) comprises a plasma generator (5) arranged to generate plasma in the gas flow (2) that, during operation of the device (1), is supplied to the main gas outlet (6).

4. Device (1) according to claim 2 and 3,
characterized in

that the plasma generator (5) comprises a high voltage supply (12) capable of applying a high voltage to an electrode (13), said electrode (13) being positioned in a chamber (4c) forming part of the main gas conduit (4).

5. Device (1) according to claim 2 and 3,
characterized in
that the gas source (3) contains nitrogen gas.

6. Device (1) according to anyone of claims 2 to 4,
characterized in
that the gas source (3) contains a gas that exhibits antimicrobial properties.

7. Device (1) according to claim 6,
characterized in
that the gas source (3) contains a gas selected from the following group: ozone, hydrogen peroxide and ethanol vapour.

8. Device (1) according to anyone of the above claims,
characterized in
that the main gas conduit (4) extends through the object gripping member (7) to the lower surface (9) where it ends in an opening forming the main gas outlet (6).

9. Device (1) according to anyone of the above claims,
characterized in
that the main gas outlet (6) is positioned in a central region of the lower surface (9).

10. Device (1) according to anyone of the above claims,
characterized in

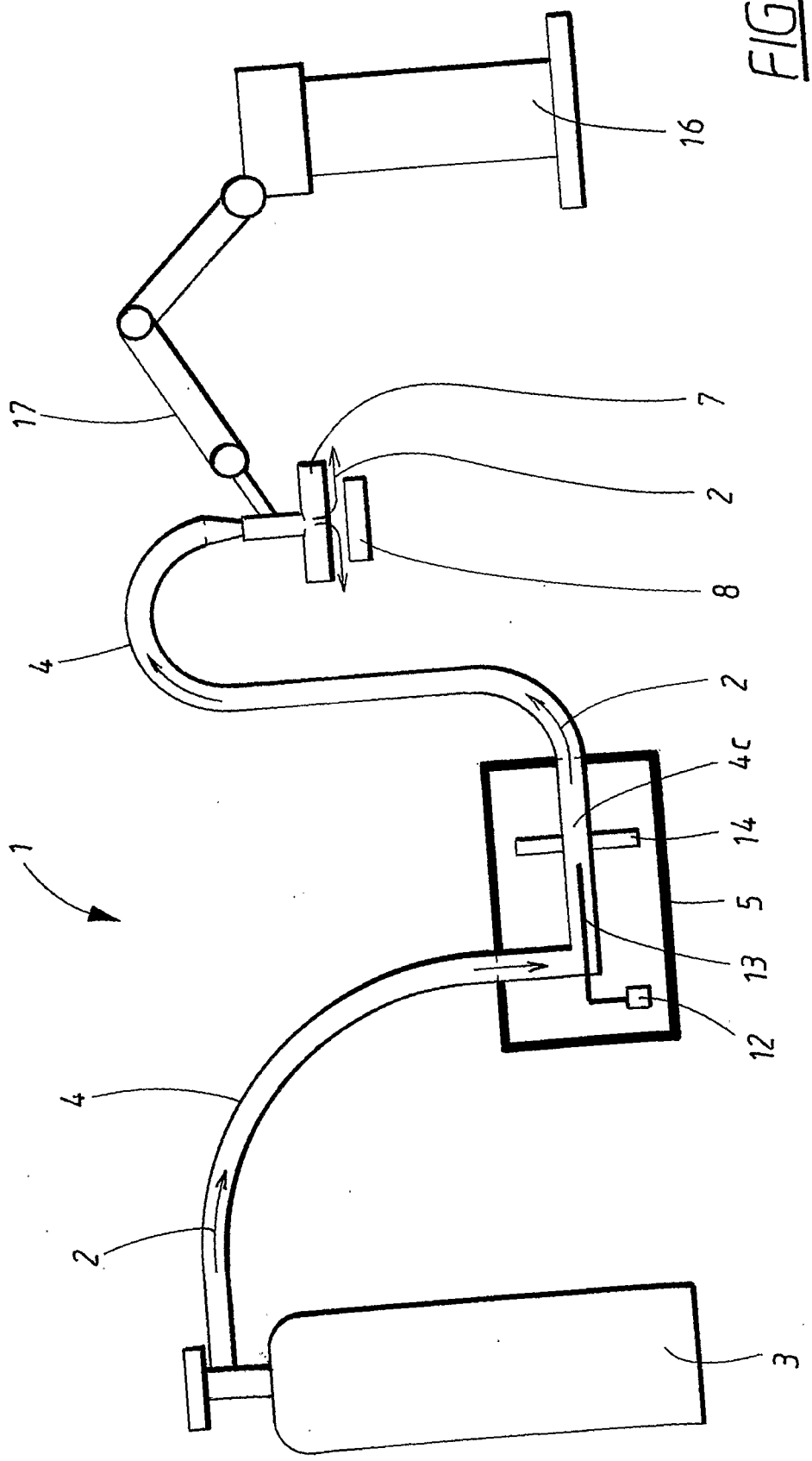
that the gas supply system comprises additional gas conduits (4', 4") and corresponding additional gas outlets (6', 6") arranged to direct a part of the gas flow (2) towards an underside (8') of the object (8).

11. Device (1) according to anyone of the above claims,
characterized in
that the object gripping member (7) is attached to an arm (17) of a robot (16).

12. Method for lifting and handling of objects (8), such as food products, using a device (1) comprising
- an object gripping member (7) having a lower surface (9) that is intended to be positioned above an object (8) to be handled when the gripping member (7) is set in an operating position, said gripping member (7) further having a main gas outlet (6) arranged in association with said surface (9), and
- a gas supply system (3, 4) for supplying a flow of gas (2) to the main gas outlet (6) during operation of the device (1),
wherein the lower surface (9) and the main gas outlet (6) are arranged so as to allow the gas to flow between the surface (9) and the object (8) when the gripping member (7) is set in its operating position such that an object lifting force is induced,
characterized in
that the method comprises the step of:
- supplying a flow of gas (2) that exhibits antimicrobial properties to the main gas outlet (6).

13. Method according to claim 12,
characterized in
that it further comprises the step of:
- exposing the gas flow (2) to a plasma generator (5) so as to give the gas antimicrobial properties.

FIG.1



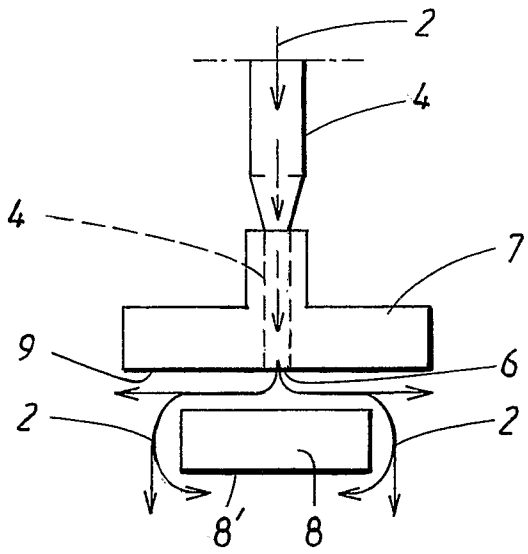


FIG. 2

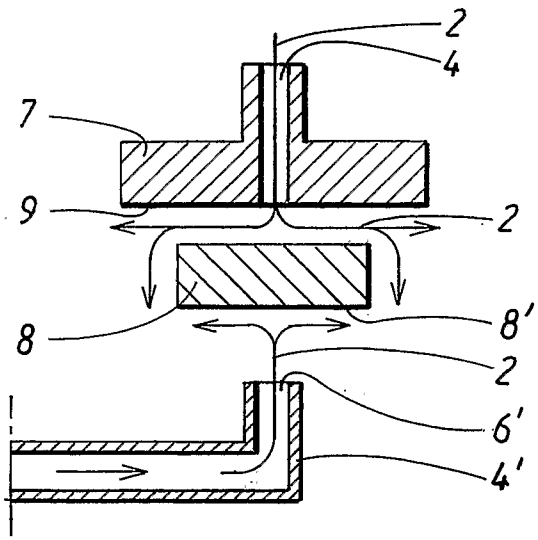


FIG. 3

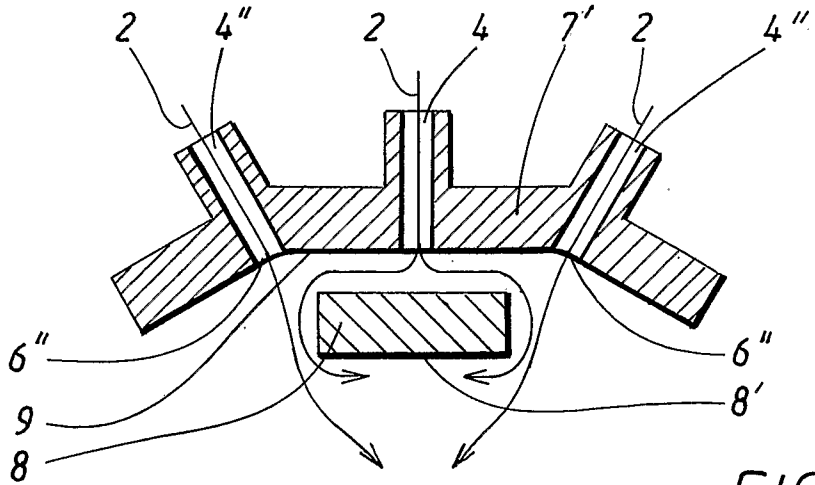


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2007/000835

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B65G, B66C, B25J, H01L, A23L, A61L, B65B

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20030033728 A1 (H. IWASAKA ET AL), 20 February 2003 (20.02.2003), paragraphs (0055), (0106)-(0109), (0112), (0126), figures	1-13
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A	US 6228330 B1 (H.W. HERRMANN ET AL), 8 May 2001 (08.05.2001), whole document	1,3,4,12,13
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A	WO 2007052018 A1 (THE UNIVERSITY OF SALFORD), 10 May 2007 (10.05.2007), whole document	1,12
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International patent classification (IPC)

B65G 47/91 (2006.01)
A23L 3/3409 (2006.01)
A61L 2/14 (2006.01)
A61L 2/20 (2006.01)
B25J 15/06 (2006.01)
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