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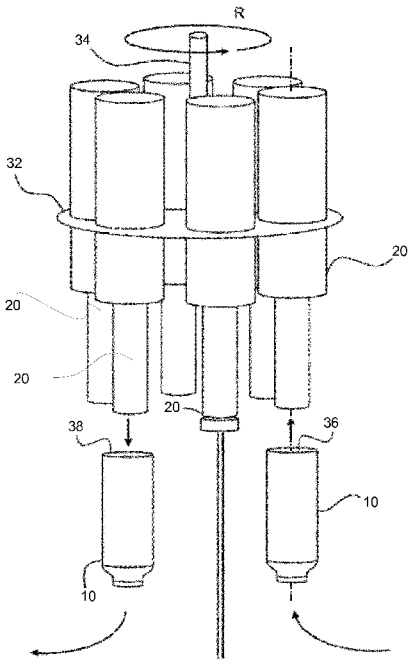


Fig. 2

(57) Abstract: A method (100) for sterilising a packaging material (1) with electron beam irradiation in a filling machine, wherein the method (100) comprises: arranging the packaging material (1) in the proximity of an electron beam emitter (20), activating the electron beam emitter (20) in order to sterilise the packaging material (1) as the packaging material (1) moves in relation to the electron beam emitter (20), and adjusting an acceleration voltage of the electron beam emitter (20) as the packaging material (1) is sterilised. An electron beam emitter (20) for sterilising a packaging material (1) with electron beam irradiation in a filling machine and a filling machine comprising a sterilising unit comprising at least one such electron beam emitter (20) are also provided.

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# A METHOD, DEVICE AND SYSTEM FOR STERILISING PACKAGING MATERIAL OF PACKAGES

## Technical Field

The present invention refers to a method, device and system for sterilising packaging material of packages. More specifically, the present invention refers to a method, device and system for sterilising using electron beam irradiation.

## Background Art

Especially for liquid food packaging, sterilisation of the packaging material used to form the packages is of high importance. When the package is to be filled, it is required that the packaging material of the package is sterilised in such a way that the product may be added aseptically, whereby the package is then being sealed.

To extend the shelf-life of the products being packed it is well known to sterilise packages before the filling operation. Depending on the desired length of the shelf-life, and whether the distribution and storage of the package is made in chilled or ambient temperature, different levels of sterilisation may be chosen. However, within the context of this specification the word sterilise is to comprise any level of microbiological killing.

For filling machines producing a ready-to-fill package, one way of sterilising is to irradiate the inside of the package, prior to filling and sealing, by electrons emitted from an electron beam unit. Such a method, and a device for realising the method, is disclosed in the international patent publication WO 2005/002973 by the same applicant.

For filling machines operating by sealing the longitudinal ends of a continuous web of packaging material into a tube, which tube is being filled, sealed, and cut to form individual packages, one way of sterilising is to irradiate the web of packaging material prior to the tube forming.

An exemplary system for sterilising using electron beam technology includes an electron beam sterilising device for emitting an electron beam along a path. The device is connected to an electron beam generator that is connected to a high voltage power supply and a filament power supply. The latter transforms power from the high voltage power supply to a suitable input voltage for a filament of the generator. The filament is preferably housed in a vacuum chamber. In operation, electrons from the filament are emitted along an electron beam path in a direction towards a target. A grid around the filament may be used for diffusing the electron beam into a more uniform beam, and for focusing the electron beam towards the target. Beam absorbers and magnetic fields

may also be used to shape the electron beam. The electrons are exiting the sterilising device through an electron exit window.

However, when sterilising either packages or a web of packaging material, there may be variations in the dimensions of the object to be sterilised. It has therefore been found that it is difficult to achieve a uniform electron beam dose throughout the entire package with one electron beam sterilising device. This is because of the different shapes of the physical portions of the package. Corners, openings, closures, bottle-like top portions, bottoms, flat walls etc. need to be sufficiently sterilised, but preferably without being over-exposed to irradiation. It is also a matter of cost, as it is preferred not being required to use more energy than necessary.

Several techniques for achieving a uniform electron beam dose have been proposed, such as in WO2007/145561 and EP2492202, where either the package is divided into several sections or the time for radiating each section is varied.

In many aspects, the prior art may be applied to successfully sterilise many types of packages. However, it is still desirable to provide an improved method and device for sterilising packaging material of packages.

## Summary

It is an object of the invention to at least partly overcome one or more of the above-identified limitations of the prior art. In particular, it is an object to fully sterilise even the most difficult package shapes with tricky, hard to reach areas or widely varying packaging diameters.

According to a first aspect of the invention, the above and other objects of the invention are achieved, in full or at least in part, by a method for sterilising a packaging material with electron beam irradiation in a filling machine is provided. The method comprises: arranging the packaging material in the proximity of an electron beam emitter, activating the electron beam emitter in order to sterilise the packaging material as the packaging material moves in relation to the electron beam emitter, and adjusting an acceleration voltage of the electron beam emitter as the packaging material is sterilised.

The method is advantageous in that by moving the packaging material in relation to the electron beam emitter and adjusting the acceleration voltage of the electron beam emitter, it is possible to fully sterilise even the most difficult package shapes.

Adjusting the acceleration voltage may be performed such that a first acceleration voltage is used for sterilising a first portion of the packaging material corresponding to a first part of a package, and a second acceleration voltage is used for sterilising a second portion of the packaging material corresponding to a second part of a package.

The different acceleration voltages are advantageous in that higher energies may penetrate further into the packaging material to reach bulk layers and lower energies may not penetrate into the packaging material to reach surface layers. More than two different acceleration voltages are possible.

Adjusting the acceleration voltage of the electron beam emitter may be performed by determining dimensions of the packaging material, and determining an acceleration voltage profile based on said determined dimensions.

Determining an acceleration voltage profile is advantageous in that it will ensure a fast and efficient sterilisation process.

The dimensions of the packaging material may comprise the distance between the packaging material and the electron beam emitter.

The distance between the packaging material and the electron beam emitter is advantageous to include in the dimensions of the packaging material because it may impact the acceleration voltage profile.

The dimensions of the packaging material may comprise the position and/or the orientation of the packaging material in relation to the electron beam emitter.

The position and/or the orientation of the packaging material in relation to the electron beam emitter is advantageous to include in the dimensions of the packaging material because it may impact the acceleration voltage profile.

The packaging material may be formed into a ready-to-fill package, and the method may further comprise inserting the electron beam emitter into the package.

Inserting the electron beam emitter into the package is advantageous in that the emitter may more easily reach different areas to be sterilised.

Activation of the electron beam emitter may be performed during inserting and/or withdrawing of the electron beam emitter from the package.

Activation during inserting and/or withdrawing is advantageous in that sterilisation may only need to be performed from within or outside of the package.

Adjusting the acceleration voltage of the electron beam emitter may be performed during inserting and/or withdrawing of the electron beam emitter from the package.

Adjusting the acceleration voltage during inserting and/or withdrawing is advantageous in that sterilisation may only need to be performed from within or outside of the package and adjustment may only be needed during inserting and/or withdrawing.

Adjusting the speed may be performed during inserting and/or withdrawing of the electron beam emitter from the package.

Adjusting the speed during inserting and/or withdrawing is advantageous in that sterilisation may only need to be performed from within or outside of the package and adjustment may only be needed during inserting and/or withdrawing.

According to a second aspect, an electron beam emitter for sterilising a packaging material with electron beam irradiation in a filling machine is provided. The electron beam emitter comprises an electron beam generator for generating an electron beam, and a control unit configured to adjust an acceleration voltage of the electron beam emitter as the packaging material is sterilised.

The control unit is advantageous in that it allows the emitter to fully sterilise even the most difficult package shapes.

The control unit may further be configured to determine dimensions of the packaging material, determining an acceleration voltage profile based on said determined dimensions, and to apply said acceleration voltage profile in order to adjust the acceleration voltage.

This configuration of the control unit is advantageous in that it further ensures a fast and efficient sterilisation process.

The control unit may be configured to load a predetermined acceleration voltage profile based on the determined dimensions of the packaging material.

Loading predetermined acceleration voltage profile is advantageous in that it allows for a streamlined process for sterilising the same type of package, e.g. during mass production.

The control unit may be configured to cause a relative movement between the electron beam emitter and the packaging material.

The relative movement is advantageous in that it makes it easier to reach different areas of the package. This may be achieved using a motor arranged on the emitter and/or operatively connected to the packaging material.

According to a third aspect, a filling machine comprising a sterilising unit comprising at least one electron beam emitter according to the second aspect is provided.

The filling machine is advantageous in that it incorporates the inventive electron beam emitter with the filling machine that fills the now sterilised package and optionally seals the package. A system is thus made with all components needed to fill a package with food product while adhering to regulations for sterilising food containers.

Still other objectives, features, aspects and advantages of the invention will appear from the following detailed description as well as from the drawings.

## Brief Description of the Drawings

Embodiments of the invention will now be described, by way of example, with reference to the accompanying schematic drawings, in which

Fig. 1 is a schematic side view of a filling machine having an electron beam emitter for sterilising a web of packaging material being transported through the filling machine;

Fig. 2 is an isometric view of parts of a filling machine, having an electron beam emitter for sterilising ready-to-fill packages prior to filling;

Figs. 3a-b are isometric views of packages to be sterilised according to an embodiment;

Figs. 3c-d are cross-sectional views of packages to be sterilised according to an embodiment;

Fig. 3e is a cross-sectional view of a web of packaging material to be sterilised according to an embodiment;

Fig. 4 is a cross-sectional view of an electron beam emitter according to an embodiment;

Figs. 5a-e are diagrams showing the acceleration voltage as a function of time during a sterilising process; and

Fig. 6 is a schematic illustration of a method for sterilising packages according to one embodiment.

## Detailed Description

In the following specification, methods of sterilisation will be described. In particular, electron beam sterilising of packaging material formed into liquid food packages will be discussed. Two different concepts are utilised; sterilisation is performed either by treating a continuous web of packaging material before it is formed

into individual packages, or sterilisation is performed by treating the interior of a ready-to-fill package before it is filled and sealed.

In Fig. 1, a filling machine is schematically shown. The filling machine is provided with two electron beam emitters 20, arranged on opposite sides of a web of packaging material 1. During operation, the electron beam emitters 20 emit radiation towards the inner and outer surface of the packaging material 1. On passage of the packaging material 1 past the electron beam emitters 20, the surface of the packaging material 1 is affected by electron beams of energy-enriched electrons from the emitters 20, whereupon both sides of the web are sterilised. The web is thereafter formed into a tube 3 in that the longitudinal edges of the web of packaging material 1 are united to one another and sealed. The tube 3 of sterilised packaging material 1 is filled with contents through a supply conduit 5, where after the tube 3 is divided into individual packaging containers by repeated transverse seals transversely of the longitudinal direction of the tube 3. The thus formed packaging units may then be separated into individual packages 10 by means of incisions in the sealing zones, and possibly be formed by folding or other means into parallelepipedic packages 10 or packages of other configuration.

Parts of a filling machine of another configuration is schematically shown in Fig. 2. The filling machine is configured to provide ready-to-fill packages 10, and to sterilise these prior to filling and sealing. Several electron beam emitters 20 are provided at a rotatable carrier 32. The rotatable carrier 32 is, in this embodiment, shaped as a wheel and is rotatable round a centre shaft 34. The direction of the rotation is illustrated by the arrow R and the rotatable movement is preferably continuous.

The filling machine further comprises packaging container conveying means, not shown, being adapted to convey the package 10 from an infeed position 36 to an outfeed position 38 synchronously with the carrier revolution movement and in alignment with the electron beam emitter 20.

The package 10 is moved synchronously with the electron beam emitter 20 and it is vertically displaced in relation to the electron beam emitter 20 during its rotation.

At the infeed position 36 the packages 10 are supplied to be sterilised. Each package 10 is aligned with a corresponding electron beam emitter 20. When the carrier 32 rotates, so that the electron beam emitter 20 and package 10 rotates from the infeed position 36 to the outfeed position 38, the package 10 is displaced towards the electron beam emitter 20 so that the electron beam emitter 20 is received in the open end of the package 10. Somewhere between the infeed and outfeed positions 36, 38

the package 10 has been displaced such that the package 10 is fully engaged with the electron beam emitter 20.

The insertion of the electron beam emitter 20 into the package 10 and the withdrawal of the electron beam emitter 20 out of the package 10 may be performed continually as one uninterrupted motion or may be two separate motions first inserting and later withdrawing the electron beam emitter 20.

While the embodiment shown only concerns inserting the electron beam emitter 20 into the package 10, an alternative embodiment uses an electron beam emitter 20 configured to sterilise the package 10 from outside of the package 10, optionally using similar relative vertical movement.

One package 10 may be arranged to be sterilised by several electron beam emitters 20. Each different emitter 20 may further be configured to use a different acceleration voltage profile to sterilise different parts of the package 10.

Some emitters 20 may be arranged to sterilise the package 10 from outside of the package 10 while others are arranged to sterilise the package 10 from inside the package 10, optionally at the same time and/or using the same emitter 20.

One electron beam emitter 20 may further be arranged to sterilise more than one package 10 at once.

Figs. 3a-b show two embodiments of partly formed packages, denoted with the reference number 10, to be sterilised by the method of the invention. As mentioned in the introduction, partly formed packages are normally closed in one end 12 and have an opening 14 at the other end. The closed end 12 may be formed as a bottom or top and the opening 14 may be an open end of a package sleeve, which later will be sealed, or for example a pour opening surrounded by a neck of a closure, which later will be provided with a cap or the like.

The package embodiment of Fig. 3b has a sealed bottom end and an opening in the top in the form of a pour opening surrounded by threaded neck of a closure. The package embodiment of Fig. 3a has an open (bottom) end and is provided in the other end with a top and a sealed closure. Fig. 3a further shows an outer surface 11, an inner surface 13 and a centre axis 15 of the package 10. A skilled person will realise that a package 10 may have any number of outer 11 and inner 13 surfaces.

The packages 10 of Figs. 3a-b have a cylindrical main body 16, and a tapered upper part 17.

In Figs. 3c-d, other shapes are described. In Fig. 3c the package 10 has a tapered main body 16, which terminates by the upper part 17 having a similar tapered

shape. The package 10 of Fig. 3d has a more complex shape, in which the main body 16 is provided with a waist. As for the previous examples, the upper part 17 is tapered.

In Fig. 3e a web of packaging material 1 is schematically illustrated. For the filling machine type illustrated in Fig. 1, the web of packaging material 1 is generally flat. However, as is illustrated in Fig. 3e, the web of packaging material 1 may have variations of its dimensions; e.g. the packaging material 1 may be formed by a first part 1a of packaging material being merged with a second part 1b of a packaging material, e.g. by a process commonly referred to as splicing. The result will be an area 1c of irregular thickness, which extends across the entire width of packaging material 1. Areas 1c of the above-described type may be provided at several positions along the web of packaging material 1.

In the following, and with reference to Fig. 4, an example of an electron beam emitter 20 and the concept of electron beam sterilisation will be briefly described. The electron beam emitter 20 comprises an electron beam generator 21 which is configured to emit an electron beam 22 along a path to the packaging material 1; in the shown example, the electron beam emitter 20 is configured to sterilise the interior of ready-to-fill packages 10.

Normally, an electron beam generator 21 is connected to a high voltage power supply 23, suitable for providing sufficient voltage to drive the electron beam generator 21 for the desired application. The electron beam generator 21 is also connected to a filament power supply 24, which transforms power from the high voltage power supply 23 to a suitable input voltage for a filament 25 of the generator 21. In addition, the high voltage power supply 23 may include a grid control 26 for controlling a grid 27 of the electron beam generator 21.

Electron beam generators 21 used in the sterilisation of packages are generally denoted low voltage electron beam units, which units normally have a voltage below 300 kV. In the disclosed design the accelerating voltage is in the order of 70-150 kV. This voltage results in kinetic (motive) energy of 70-150 keV in respect of each electron.

The filament 25 may be made of tungsten and may be housed in a vacuum chamber. In an exemplary embodiment, the vacuum chamber may be hermetically sealed. In operation, an electrical current is fed through the filament 25 and the electrical resistance of the filament 25 causes the filament 25 to be heated to a temperature in the order of 2000°C. This heating causes the filament 25 to emit a cloud of electrons. The electrons are emitted along an electron beam path in a direction

towards the target area, in this case an area within the package 10. The grid 27, placed between the filament 25 and the electron beam exit window 28, is provided with a number of openings and is used for diffusing the electron beam 22 into a more uniform beam, and for focusing the electron beam 22 towards the target area.

In the embodiment shown the electron beam generator 21 is housed in the electron beam emitter 20. The electron beam emitter 20 comprises a vacuum chamber 29, which may be the same vacuum chamber as the vacuum chamber of the electron beam generator 21, though other embodiments are possible. The electron beam emitter 20 is further provided with an electron exit window 28. The window 28 may be made of a metallic foil, such as for example titanium, and may have a thickness in the order of 4-12 µm. A supporting net formed of aluminium or copper supports the foil from inside of the electron beam generator 21. The electrons are exiting the vacuum chamber 29 through the exit window 29.

In this embodiment the electron beam emitter 20 with the electron beam generator 21 inside has the form of a cylinder 30 with a substantially circular cross section and the exit window 28 is being located in a first end of the cylinder 30. It should however be realised that for the filling machine of Fig. 1, a more laterally elongated configuration of the electron beam emitter 20 is preferred.

In another embodiment the electron beam generator 21 and the electron beam emitter 20 are of course connected, but only the electron beam emitter 20 is cooperating with the package 10, i.e. the electron beam emitter 20 is, at least to a portion, positioned or moved either inside or around the package 10 during irradiation. The vacuum chambers (not shown from outside) are then in communication with each other, and the electron beam emitter 20 functions as an extension, or nozzle, of the electron beam generator 21, i.e. it is used to reach the package 10 to be sterilised.

The electron beam generator 21 may be connected to more than one electron beam emitter 20. A support (not shown) is preferably provided for supporting the target, i.e. the package 10, within the target area. The support may for example be a conventional carrier of a conveyor which transports the package 10 through a sterilisation chamber. During sterilisation of a package 10 like the one in Fig. 3a, the package 10 may be placed upside down (i.e. the top is located downwards) in the support.

Further, during sterilisation a relative movement is performed between the package 10 and the electron beam emitter 20 as explained earlier with reference to Fig. 2. Either the electron beam emitter 20 is lowered into or around the package 10, or

the package 10 is raised to surround the electron beam emitter 20, or each is moving towards each other. To accomplish such, the support may be either stationary or configured to perform a motion towards and from the electron beam emitter 20.

The relative movement between the package 10 and the electron beam emitter 20 may be achieved in many different ways. For example, it may comprise a slow lowering of the electron beam emitter 20 into the package 10 followed by a short stop and a quick raise out of the package 10. Alternatively, the relative movement may comprise a lowering and a raise without any stop. As a further alternative, the lowering and the raise is made very quick, but with a number of short stops during the way.

An electron beam emitter 20 may be configured for optimal irradiation of the package type that it will irradiate. The features of the electron beam emitter 20 that may be modified to achieve the different irradiation characteristics needed for the different package types are for example the shape and size of the electron beam emitter 20 and the number of electron beam exit windows 28 and their placement and shape. To further change the characteristics of the electron beam 22 the filament 25 and the control grid 27 may be modified.

Further, the relative movement between the package 10 and the electron beam emitter 20, which is schematically shown by vertically arranged arrow in Fig. 4, is configured for optimal irradiation together with the electron beam emitter 20.

So far, packages 10 have been described as having a circular cross-section. However, it should be understood that the package cross section may have almost any shape such as round, square, rectangular, oval, triangular, orthogonal or any other shape.

The electron beam emitter 20 and its use has been described in general. In particular, an important embodiment of the invention revolves around providing a single electron beam emitter 20 that may be configured to sterilise any package 10 without needing any specialisation or unique dimensions. Such electron beam emitter 20 is described below, however it should be understood that any one variable setting may alternatively or additionally be implemented using additional electron beam emitters 20.

In one embodiment, the electron beam emitter 20 comprises a control unit 40 (see Fig. 4) configured to cause the electron beam generator 21 to switch the energy of the electrons during sterilisation.

The energy level should preferably be set to a value where the electrons of the electron beam 22 are absorbed in the inside surface layer of the packaging material 1. This layer often contains micro-organisms to be sterilised. Hence, the control unit 40

may be configured to set the energy of the electrons to such energy level when the electron beam 22 is directed at a surface of the packaging material 1 containing micro-organisms to be sterilised.

As the physical dimensions of the packaging material 1 may vary, either by irregular areas 1c of the web of packaging material 1 as shown in Fig. 3e, or by package shape variations as shown in Figs. 3a-d, the inventors have realised that improved sterilisation may be achieved by adjusting the acceleration voltage as a function of the packaging material dimensions.

By adjusting the energy level of the electron beam 22, a different distance to the target surface may be handled by lowering the energy when the surface is close to the electron exit window 28 and increasing the energy when the surface is far away from the electron exit window 28.

A complex package shape may have so called hidden areas, i.e. areas which are more difficult to reach for the electron beam 22. Hidden areas may e.g. include folds or tilted surfaces which are not in direct reach for the electron beam 22. However, by increasing the acceleration voltage of the electron beam emitter 20 the penetration of the electrons into the material is also increased, thereby increasing sterilisation of the hidden areas. Hence, by adjusting the acceleration voltage during sterilisation it is possible to have a low energy for easily accessed surfaces, and a higher energy for more difficult-to-reach areas.

The electron beam 22 may be directional or omni-directional. Additionally or alternatively, the electron beam emitter 20 may be configured to move relative to the package 10, either by causing movement of the electron beam emitter 20, the package 10 or both.

All of the movement may be at a constant speed or a varied speed. The constant speed may use energy variation as described previously to adjust to irregular package shapes. By using varied speed, a smaller energy variation may be needed compared to the constant speed, but still may be needed to reach bulk or to provide an even more exact shape adjustments.

Now turning to Figs. 5a-e, acceleration voltage as a function of time is illustrated. For all of these examples, a constant speed of movement is used, however a varied speed is also possible.

In Fig. 5a, an acceleration voltage profile is shown which is suitable for sterilising the package shown in Fig. 3a. Initially, before t1, the acceleration voltage is at a low level. This time corresponds to the time required to insert the electron beam

emitter 20 fully into the package 10. At t1 the electron beam emitter 20 is raised (or the package 10 is lowered). As the neck of the package 10 is tapered, as the diameter increases, the acceleration voltage is increased until the electron exit window 28 is vertically aligned with the position where the package shape is cylindrical. From here, the acceleration voltage is essentially constant.

In Fig. 5b an acceleration voltage curve is shown, which is suitable for the package shown in Fig. 3b. As can be seen, it is basically a reversed version of the profile of Fig. 5a.

In Fig. 5c an acceleration voltage profile is shown for use with the package 10 shown in Fig. 3c. When starting to be withdrawn from the package 10, the electron beam emitter 20 is configured to emit electrons of an initially high energy, which continuously decreases during the sterilisation process.

In Fig. 5d another example of an acceleration voltage profile is shown, for use with the package 10 shown in Fig. 5d.

In Fig. 5e an example of the acceleration voltage profile is shown, for use by the emitters 20 shown in Fig. 1, i.e. the emitters 20 arranged to sterilise the web of packaging material 1. When the irregular shape of the packaging material 1 is passing the electron beam emitters 20, the acceleration voltage is adjusted to ensure a sufficient sterilisation of the web of packaging material 1.

Fig. 6 shows a schematic illustration of a method 100 for sterilising packaging material 1 with electron beam irradiation in a filling machine. Fig. 6 shows three different, distinct method steps 110-130 in sequential order. It should be understood that any and all of the method steps 110-130 may be combined with any other or skipped entirely, reordered or redone. Each step will thusly be described individually.

A first step 110 comprises arranging at least one electron beam emitter 20 in a position close to the packaging material 1. This step 110 may be performed by inserting the electron beam emitter 20 into a ready-to-fill package, or by feeding a web of packaging material 11 pass the electron beam emitter 20, as described previously.

A surface sterilising step 120 comprises sterilising at least one inner surface of the packaging material 1 using electrons at a level where the electrons of the electron beam 22 are absorbed in the surface layer of the packaging material 1, thereby sterilising the surface layer of the packaging material 1.

An adjusting step 130 comprises adjusting the acceleration voltage of the electron beam emitter 20 to change the energy of the electrons, whereby the same

electron beam emitter 20 is capable of sterilising both the surface layer and the bulk of a packaging material 1.

Steps 120, 130 are preferably performed during a relative movement between the packaging material 1 and the electron beam emitter 20, as described earlier.

From the description above follows that, although various embodiments of the invention have been described and shown, the invention is not restricted thereto, but may also be embodied in other ways within the scope of the subject-matter defined in the following claims.

# CLAIMS

1. A method (100) for sterilising a packaging material (1) with electron beam irradiation in a filling machine, wherein the method (100) comprises:

arranging the packaging material (1) in the proximity of an electron beam emitter (20),

activating the electron beam emitter (20) in order to sterilise the packaging material (1) as the packaging material (1) moves in relation to the electron beam emitter (20), and

adjusting an acceleration voltage of the electron beam emitter (20) as the packaging material (1) is sterilised.

2. The method (100) according to claim 1, wherein adjusting the acceleration voltage is performed such that a first acceleration voltage is used for sterilising a first portion of the packaging material (1) corresponding to a first part of a package (10), and a second acceleration voltage is used for sterilising a second portion of the packaging material (1) corresponding to a second part of a package (10).

3. The method (100) according to claim 1 or 2, wherein adjusting the acceleration voltage of the electron beam emitter (20) is performed by determining dimensions of the packaging material (1), and determining an acceleration voltage profile based on said determined dimensions.

4. The method (100) according to claim 3, wherein the dimensions of the packaging material (1) comprises the distance between the packaging material (1) and the electron beam emitter (20).

5. The method (100) according to claim 3 or 4, wherein the dimensions of the packaging material comprises the position and/or the orientation of the packaging material (1) in relation to the electron beam emitter (20).

6. The method (100) according to any of the preceding claims, wherein the packaging material (1) is formed into a ready-to-fill package (10), and wherein the

method (100) further comprises inserting the electron beam emitter (20) into the package (10).

7. The method (100) according to claim 6, wherein activation of the electron beam emitter (20) is performed during inserting and/or withdrawing of the electron beam emitter (20) from the package (10).

8. The method (100) according to claim 6 or 7, wherein adjusting the acceleration voltage of the electron beam emitter (20) is performed during inserting and/or withdrawing of the electron beam emitter (20) from the package (10).

9. The method (100) according to any of claims 6-8, further comprising adjusting the speed during inserting and/or withdrawing of the electron beam emitter (20) from the package (10).

10. An electron beam emitter (20) for sterilising a packaging material (1) with electron beam irradiation in a filling machine, comprising an electron beam generator (21) for generating an electron beam (22), and a control unit (40) configured to adjust an acceleration voltage of the electron beam emitter (20) as the packaging material (1) is sterilised.

11. The electron beam emitter (20) according to claim 10, wherein the control unit (40) is further configured to determine dimensions of the packaging material (1), determining an acceleration voltage profile based on said determined dimensions, and to apply said acceleration voltage profile in order to adjust the acceleration voltage.

12. The electron beam emitter (20) according to claim 11, wherein the control unit (40) is configured to load a predetermined acceleration voltage profile based on the determined dimensions of the packaging material (1).

13. The electron beam emitter (20) according to any of claims 10-12, wherein the control unit (40) is configured to cause a relative movement between the electron beam emitter (20) and the packaging material (1).

14. A filling machine, comprising a sterilising unit comprising at least one electron beam emitter (20) according to any one of the claims 10 to 13.

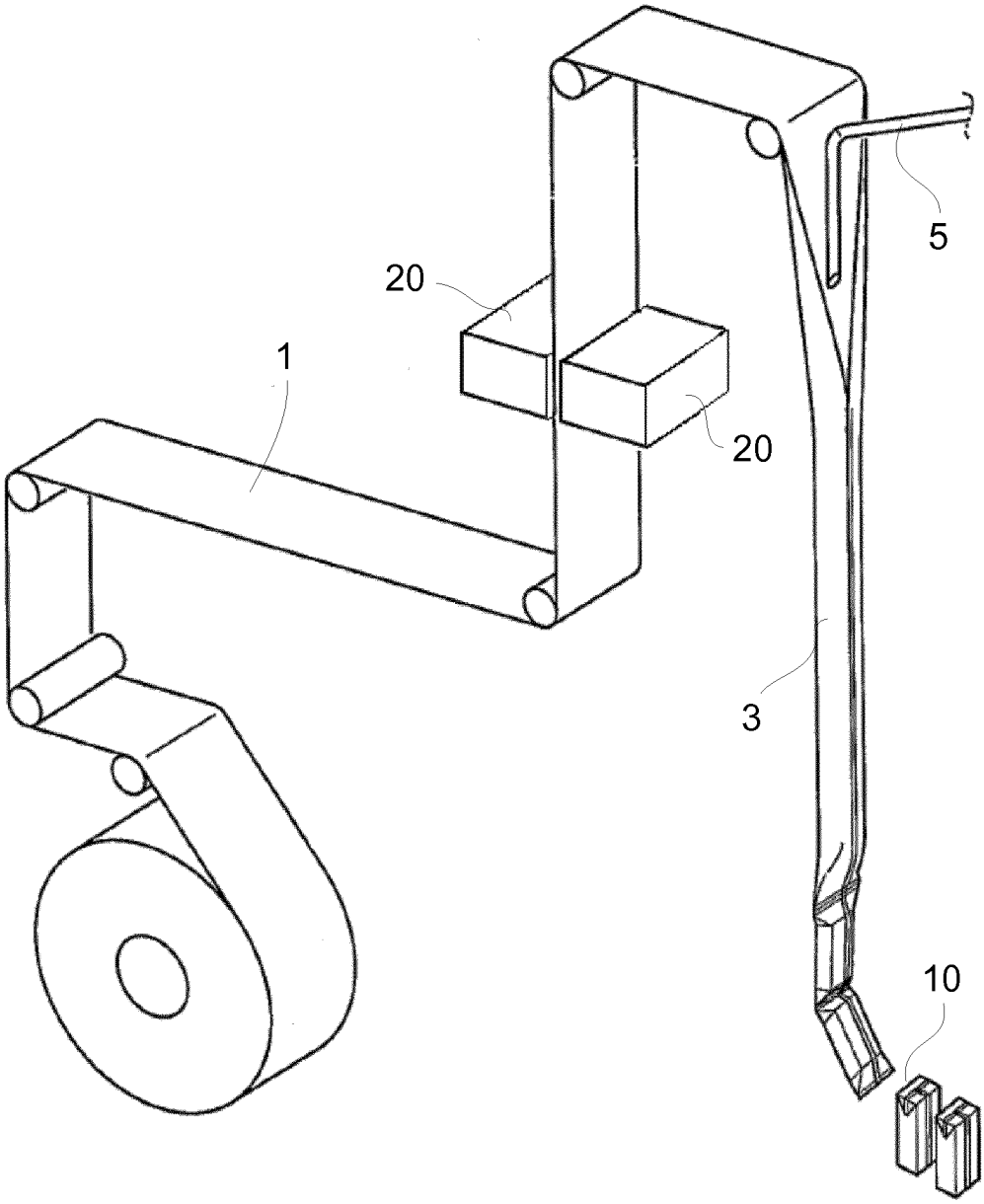


Fig. 1

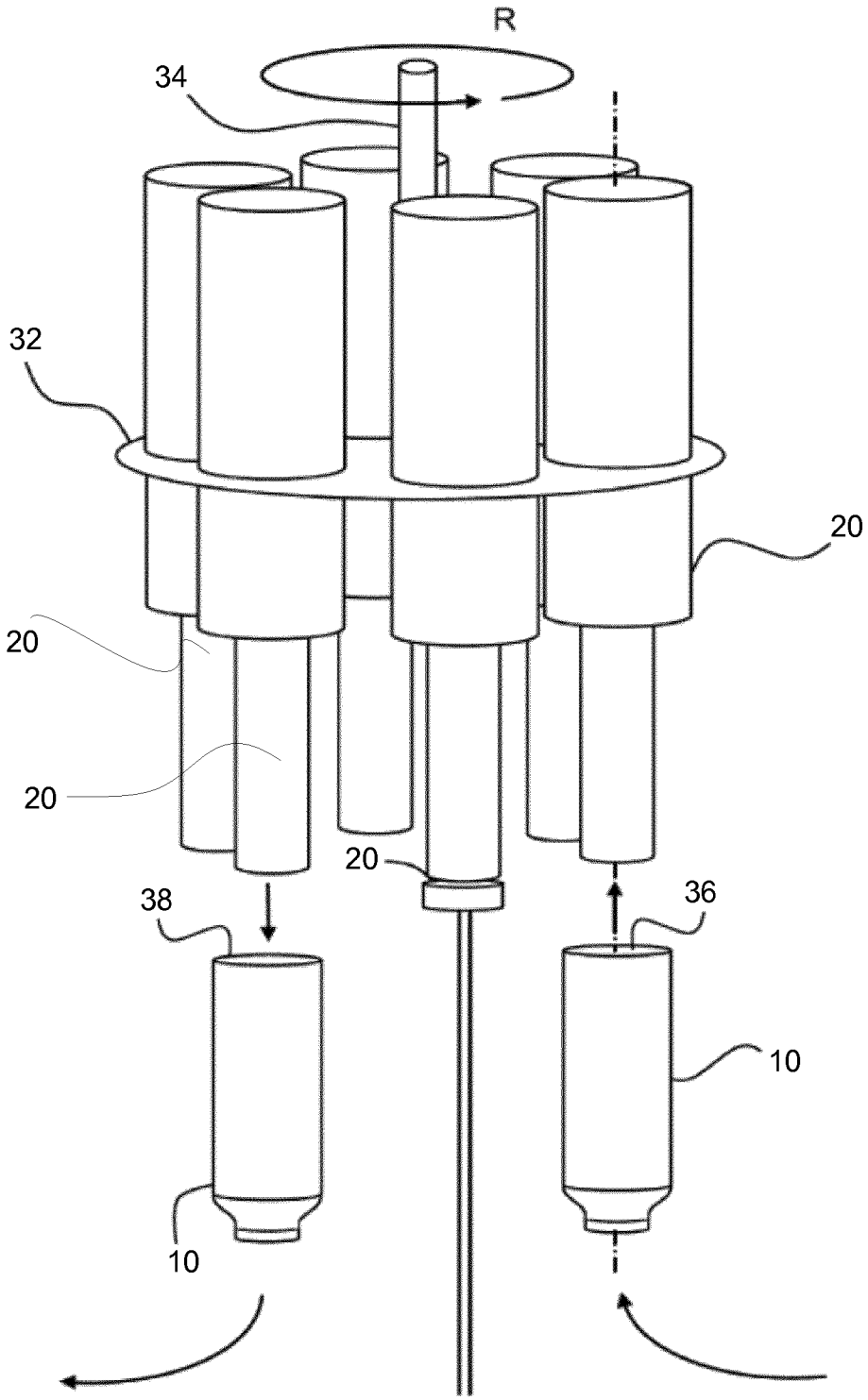


Fig. 2

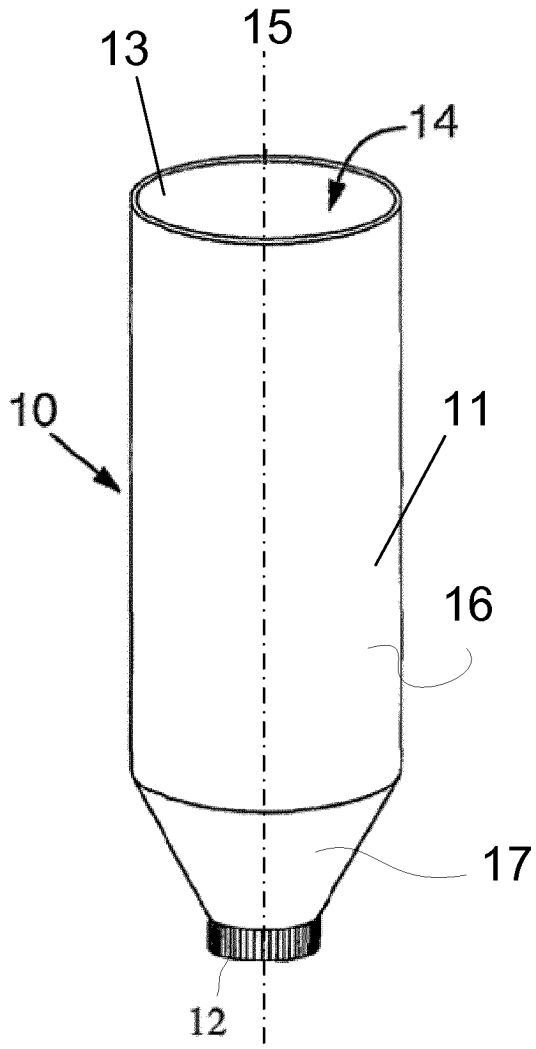


Fig. 3a

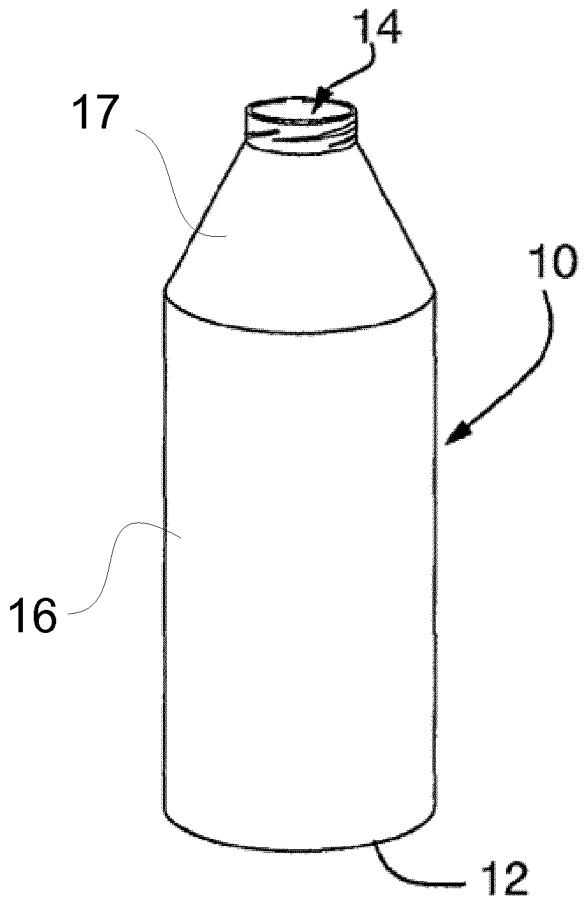


Fig. 3b

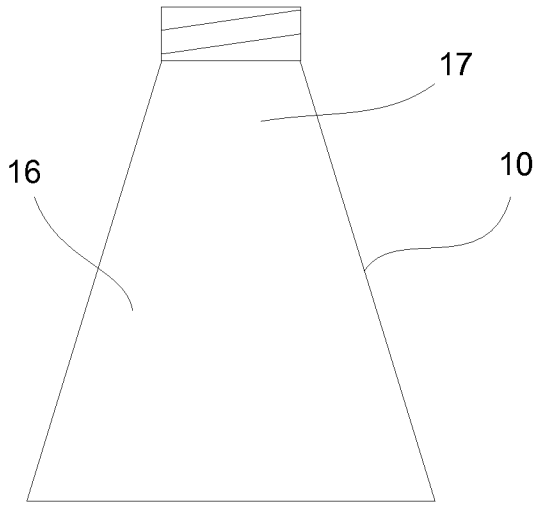


Fig. 3c

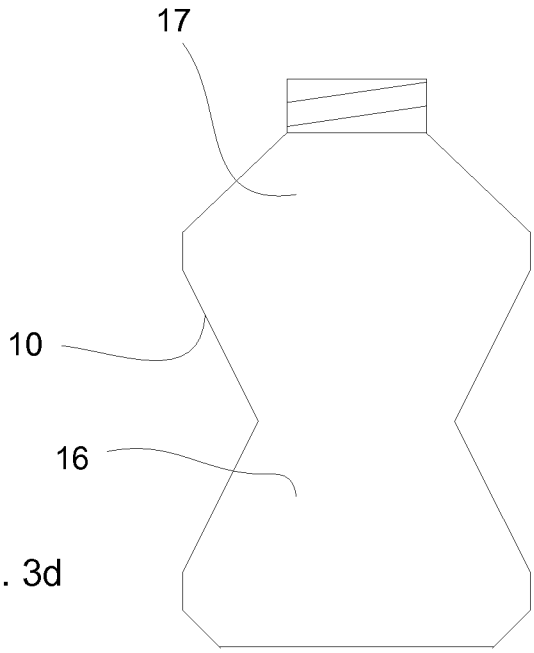


Fig. 3d

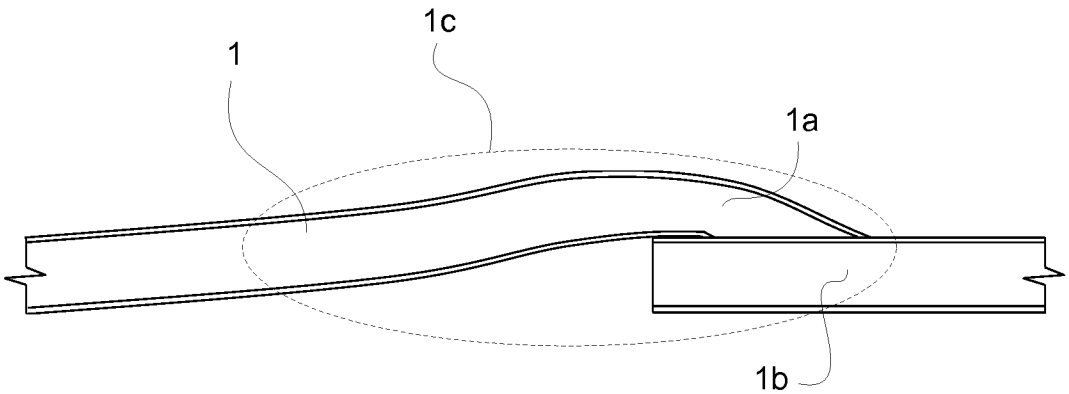


Fig. 3e

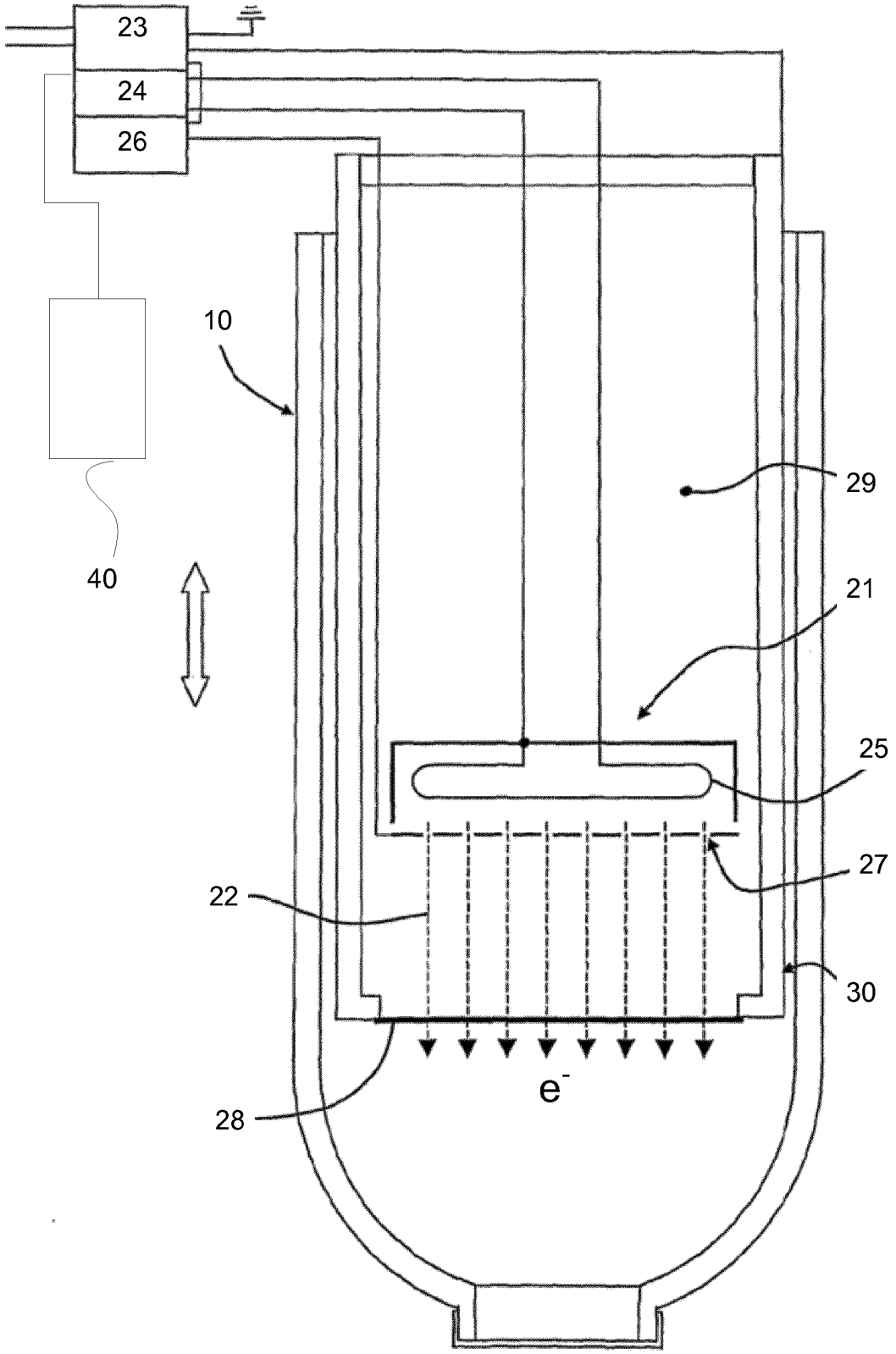


Fig. 4

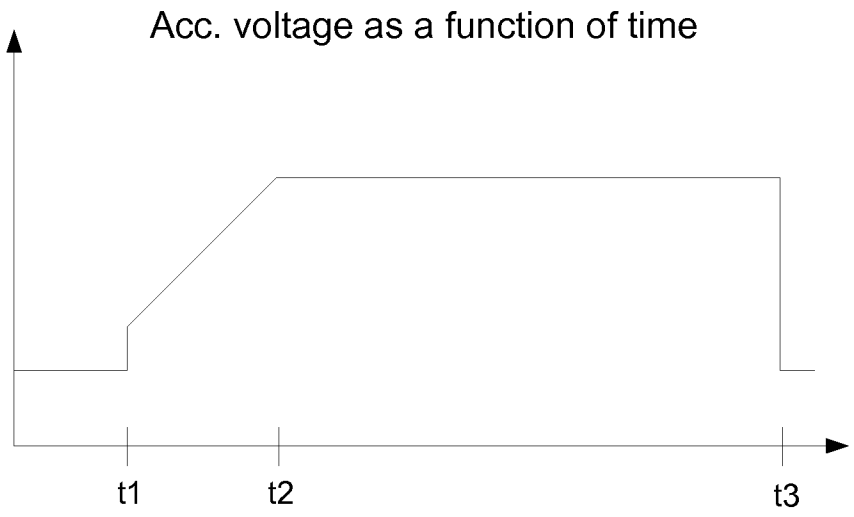
Acc. voltage as a function of time
t1
t2
t3

Fig. 5a

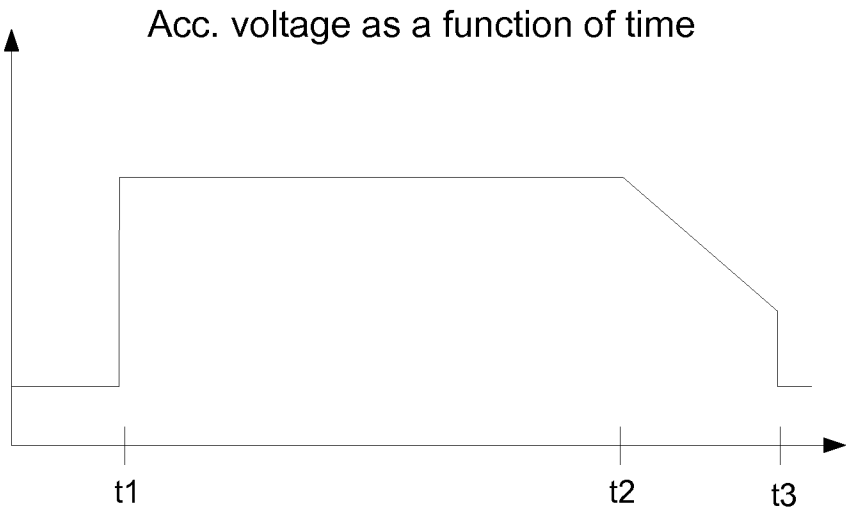
Acc. voltage as a function of time
t1
t2
t3

Fig. 5b

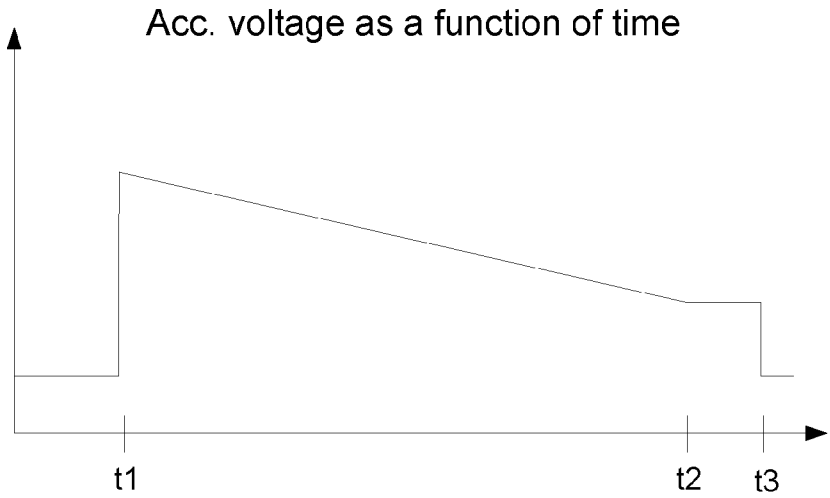


Fig. 5c

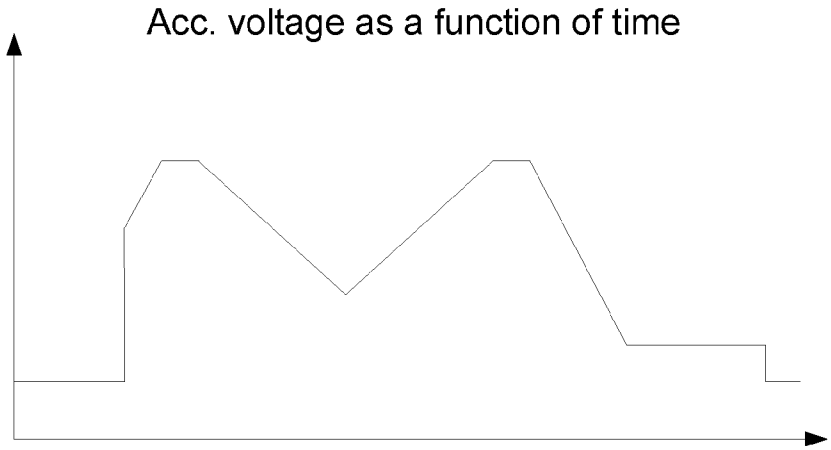


Fig. 5d

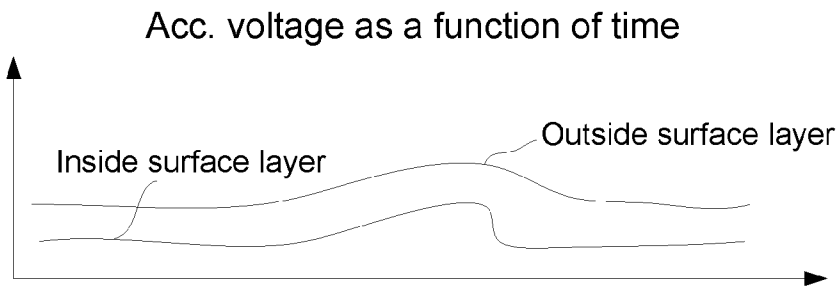


Fig. 5e

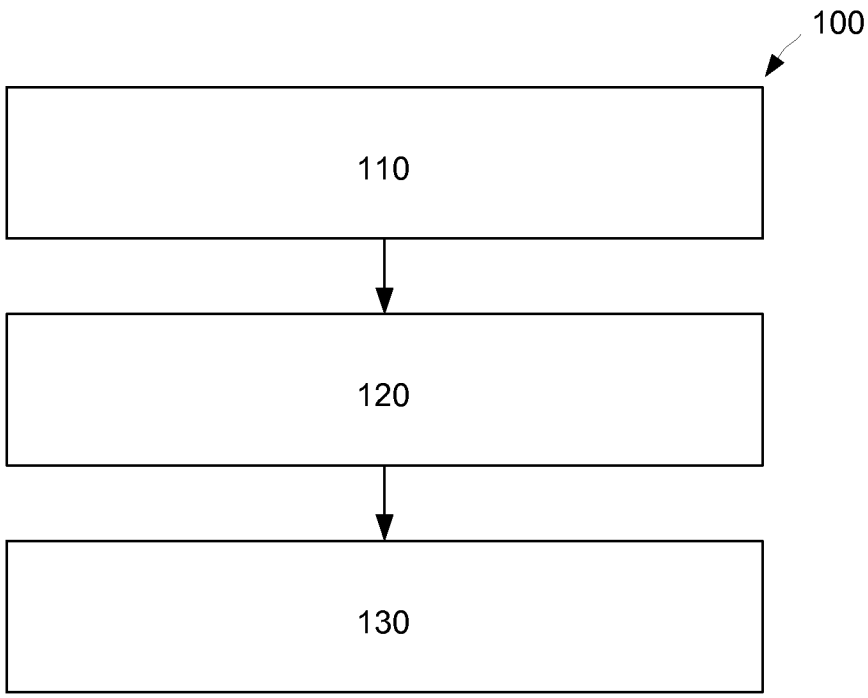


Fig. 6

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/082460

A. CLASSIFICATION OF SUBJECT MATTER
INV. B65B55/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B65B

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | WO 2016/114108 A1 (HITACHI SHIPBUILDING ENG CO [JP]) 21 July 2016 (2016-07-21) | 1,2, 6-10,13, 14 |
| Y | abstract<br>paragraph [0002]<br>figures 2-3, 5-6<br>paragraph [0032] - paragraph [0033]<br>paragraph [0041] - paragraph [0044] | 3-5,11, 12 |
| | ----- | |
| Y | EP 2 755 052 A1 (TETRA LAVAL HOLDINGS & FINANCE [CH]) 16 July 2014 (2014-07-16)<br>abstract<br>paragraph [0011]<br>paragraph [0077] | 3-5,11, 12 |
| | ----- | |
| A | WO 2014/086675 A2 (TETRA LAVAL HOLDINGS & FAINANCE SA) 12 June 2014 (2014-06-12)<br>abstract<br>page 18, line 23 - line 30 | 1-14 |
| | ----- | |

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 10 January 2020 | 22/01/2020 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Damiani, Alberto |

1

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/082460

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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| | | JP 2018503565 A | 08-02-2018 |
| | | JP 2018508933 A | 29-03-2018 |
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| WO 2014086675 A2 | 12-06-2014 | EP 2926166 A2 | 07-10-2015 |
| | | JP 6240211 B2 | 29-11-2017 |
| | | JP 2016500437 A | 12-01-2016 |
| | | WO 2014086675 A2 | 12-06-2014 |