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(54) **APPARATUS AND METHOD FOR CRUST FREEZING ARTICLES**

(57) In order to overcome the limitations and problems that earlier apparatus and methods have experienced, an apparatus (10) for crust freezing articles (12), in particular cylindrically shaped articles, for example cylindrically shaped food articles or food logs, on multiple transport paths (14, 16) of at least one conveyor (18) is proposed, said apparatus (10) comprising:
- an enclosure (20) having a ceiling (22), a floor (24) and a plurality of sidewalls (26),
- the at least one conveyor (18) for transporting the articles (12) through the enclosure (20) and defining at least the first transport path (14) and the second transport path (16),
- a cryogen gas supply (29),
- at least one gas circulation device (30) positioned for circulating cryogen gas (33) along a gas circulation path (34), in particular along a cryogen gas circulation path, across short axes (19) of the first transport path (14) and of the second transport path (16), said gas circulation device (30) in particular comprising a centrifugal blower, for example a plurality of inline centrifugal blowers, positioned laterally to the at least one conveyor (18),
- a gas impermeable barrier (28) positioned between the first transport path (14) and the second transport path (16), and defining the gas circulation path (34) whereby the cryogen gas (33) passes across the articles (12) on the first transport path (14) and returns to the gas circulation device (30) passing across the articles (12) on the second transport path (16), said gas circulation path (34) in particular being substantially perpendicular to the first transport path (14) and to the second transport path (16).

A related method of crust freezing articles (12), in particular cylindrically shaped articles, for example cylindrically shaped food articles or food logs, in a freezing apparatus (10), is also proposed.

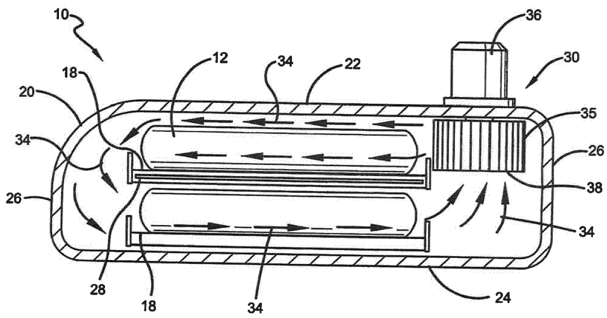

FIG. 1

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Description

Technical field of the present invention

[0001] The present invention relates to an apparatus for and to a method of crust freezing articles, in particular cylindrically shaped articles, for example cylindrically shaped food articles or food logs.

Technological background of the present invention

[0002] Ready-to-eat (RTE) meat logs, or chubs, are rolls of processed meat which can be, for example, of a diameter from about three inches (7.62 cm) to about six inches (15.24 cm), and up to about 72 inches (1.83 m) in length. After the meat logs are processed, i.e. prepared, they must be sliced for market.

[0003] In order to slice the meat logs in a cost effective manner, especially in consideration of the amount of material that must be sliced, it is necessary to cool and preferably freeze the surface layer of the meat log for proper and effective slicing.

[0004] The cylindrical shape of the meat log makes them difficult to freeze in standard chilling tunnels and, in those situations where the crust is frozen unevenly, the slicing process is less effective and the cutting device becomes clogged with the meat material.

[0005] The market for RTE products offered in supermarkets is increasing, as is the need for cost-effective slicing processes which do not adversely affect product yields.

[0006] An unfrozen meat log impacted by a slicing blade is cut less effectively and less accurately than would result when using a surface frozen meat log. Conventional meat log cutting apparatus, upon retraction of the blade for a subsequent cut, cause portions of the product material to adhere to the blade, which portions are displaced about the processing area, while some of the material is retained on the blade surface during the subsequent cut.

[0007] This causes the need for increased cleaning, maintenance and repair of the blade and support for the related machinery, and results in a less effective processing of the meat log. In machines conducting 1000 slices a minute, this could result in a five percent to fifteen percent loss or reduction in yield of product being processed.

[0008] Conventional cryogenic freezing tunnels have been adapted to crust freeze the surface of meat logs. Unfortunately, the placement of fans and the configuration of such tunnels are not optimum for the crust freezing process, and therefore longer tunnels are required to achieve crusting requirements.

[0009] Additionally, because axial flow fans are employed to generate gas flows only from above the logs as they are conveyed through the freezer, the top surface of the logs may be over-frozen.

[0010] It is most desirable in meat log crusting applications that an even crust is developed completely around the log for optimum slicing.

Disclosure of the present invention: object, solution, advantages

[0011] Starting from the disadvantages and shortcomings as described above as well as taking the prior art as discussed into account, an object of the present invention is to overcome the limitations and problems that earlier apparatus and methods have experienced.

[0012] This object is accomplished by an apparatus comprising the features of claim 1 as well as by a method comprising the features of claim 7. Advantageous embodiments, expedient improvements and other optional features of the present invention are set forth herein and disclosed in the respective dependent claims.

[0013] The present invention basically provides for a product crust freezing apparatus and method, more specifically for a high gas-flow crust freezer apparatus and method, which uniformly freezes the exterior surface crust of at least one article, in particular of at least one cylindrically shaped article, for example of at least one cylindrically shaped food article or food log, such as meat log.

[0014] There is provided herein an apparatus for crust freezing articles, in particular cylindrically shaped articles, for example cylindrically shaped food articles or food logs, on multiple conveyor paths, comprising:

- an enclosure having a ceiling, a floor and a plurality of sidewalls,
- at least one conveyor for transporting articles through the enclosure and defining at least a first transport path and a second transport path,
- a cryogen gas supply,
- at least one gas circulation device positioned for circulating cryogen gas along a gas circulation path across short axes of the first and second transport paths,
- a gas impermeable barrier, in particular a divider, for example a divider plate, positioned between the first transport path and the second transport path, and defining the gas circulation path whereby the cryogen gas passes across

articles on the first transport path and returns to the gas circulation device passing across articles on the second transport path.

[0015] In certain embodiments, the first transport path and the second transport path may be defined by a plurality of independent conveyors, and the divider plate may be positioned between the independent conveyors.
[0016] In certain embodiments, the first transport path may be configured to transport the articles from an entrance sidewall to an exit sidewall on a first conveyor, and the second transport path may be configured to transport the articles from an entrance sidewall to an exit sidewall on a second conveyor.
[0017] In certain embodiments, the first transport path and the second transport path may be defined by an upper and a lower run of a conveyor, and the divider plate may be positioned between the upper and lower runs of the conveyor.
[0018] In certain embodiments, the first transport path may be configured to transport the articles from a front entrance sidewall to an exit sidewall on a feed run of the conveyor, and the second transport path may be configured to transport the articles on a return run of the conveyor from an entrance to an exit on a lateral sidewall.
[0019] In certain embodiments, the gas circulation path may be substantially perpendicular to the first and second transport paths.
[0020] In certain embodiments, the gas circulation device may comprise a centrifugal blower positioned laterally to the at least one conveyor.
[0021] In certain embodiments, the gas circulation device may comprise a plurality of inline centrifugal blowers positioned laterally to the at least one conveyor.
[0022] In certain embodiments, the at least one conveyor may be adapted to receive and transport cylindrically shaped food logs with a longitudinal axis of each of the food logs positioned in a direction similar to a direction of the short axis of the conveyor.
[0023] There is also provided herein a method of crust freezing articles, in particular cylindrically shaped articles, for example cylindrically shaped food articles or food logs, in a freezer, comprising:

- transporting a first portion of articles along a first transport path, and a second portion of articles along a second transport path within the freezer,
- establishing a cryogen gas circulation path from at least one gas circulation device across short axes of the first and second transport paths, whereby cryogen gas from the gas circulation device passes across the first portion of articles on the first transport path and returns to the gas circulation device by passing across articles on the second transport path.

[0024] In certain embodiments, the gas circulation path across articles on the first transport path may be isolated from the gas circulation path across articles on the second transport path.
[0025] In certain embodiments, the first transport path and the second transport path may be defined by a plurality of independent conveyors, wherein a gas impermeable barrier, in particular a divider, for example a divider plate, may be positioned between the independent conveyors.
[0026] In certain embodiments, the first portion of the articles may be transported along the first transport path from an entrance sidewall to an exit sidewall of the freezer on a first conveyor, and the second portion of the articles may be transported along the second transport path from the entrance sidewall to the exit sidewall of the freezer on a second conveyor.
[0027] In certain embodiments, the first transport path and the second transport path may be defined by an upper and a lower run of a conveyor, wherein a gas impermeable barrier, in particular a divider, for example a divider plate, may be positioned between the upper and lower runs of the conveyor.
[0028] In certain embodiments, the first portion of the articles may be transported along the first transport path from a front entrance sidewall to an exit sidewall in the freezer on a feed run of the conveyor, and the second portion of the articles may be transported along the second transport path on a return run of the conveyor from an entrance to an exit on a lateral sidewall of the freezer.
[0029] In certain embodiments, the gas circulation path may be established substantially perpendicular to the first and second transport paths.
[0030] In certain embodiments, the gas circulation device may comprise a centrifugal blower positioned laterally to the at least one conveyor.
[0031] In certain embodiments, the gas circulation device may comprise a plurality of inline centrifugal blowers positioned laterally to the at least one conveyor.
[0032] In certain embodiments, the articles may be received and transported with a longitudinal axis of each of the articles being in a direction similar to a direction of the short axes of the first and second transport paths.
[0033] In certain embodiments, a gas velocity of the cryogen gas in the gas circulation path may be between about twenty meters per second and about thirty meters per second.

[0034] The present embodiments are directed to an apparatus for crust freezing articles, being particularly efficient for crust freezing generally cylindrically shaped articles in a freezer, and the associated method of crust freezing such articles.

[0035] The problematic issues disclosed above that are encountered with crust freezing cylindrical or rectangular articles such as deli logs, or meat logs or loaves (hereinafter also referred to collectively as "logs" or "articles"), are reduced or eliminated by these embodiments.

[0036] In the present embodiments, gas flow is generated and applied in the freezer so that the entire log, transported on a conveyor belt, is surrounded by the gas flow at a constant velocity, resulting in an even or uniform crust freeze.

[0037] The gas velocities generated by the present embodiments are up to two times to three times greater than in prior, conventional crust freezers, and the gas flow travels across the width of the conveyor belt.

[0038] Logs can be loaded optimally by the present embodiments, for example lengthwise across the width of the conveyor, such as a conventional conveyor belt, and the size of the freezing tunnel can be reduced by commensurate orders of magnitude.

[0039] As a result of the flow path created by the present embodiments, logs can be frozen on a plurality of conveyor transport paths, thereby reducing further the footprint of the freezing system.

[0040] Cryogenic gas is circulated in the present cooler/freezer by a series of inline centrifugal blowers, and the position of the blower(s) is laterally offset from the conveyor(s), as compared to a conventional crust freezer where axial blowers are positioned above the conveyor. Cryogen may be introduced into the freezer by spraying liquid or solid cryogen into the circulating gas at any point in the gas circulation loop.

[0041] In certain embodiments, there are two independent integrated conveyor belts running through the crusting tunnel. Articles to be crust frozen, such as deli or meat logs are placed on the conveyor belts and are transported through the freezing zone. Ideally, the articles may be loaded onto both belts simultaneously.

[0042] The internal gas circulation path is designed and configured such that high velocity cryogen gas impacts the articles on both the top and bottom belts in a single circulation path. There is no independent return path required for this gas flow circuit, which results in an extremely efficient utilization of circulating gas in the freezer.

[0043] In certain embodiments, the coolant or cryogen may comprise nitrogen or carbon dioxide. The term "cryogen" as used herein is similar to the term "coolant", and such terminology is not intended to necessarily be limited to materials which have a purely cryogenic effect, although that meaning is intended to be included in the use of "cryogen". The term "coolant" as used herein means any material or mixture which provides a cooling effect to a product, such as for example the logs or articles herein.

[0044] The cryogen gas is pressurized by inline centrifugal blowers and is forced directly across the articles, such as meat logs, transported on the conveyors. The gas circulation path originates with the blower, travels laterally to contact the articles on one conveyor run, and is deflected by a sidewall of the freezer to the blower inlet along a return path contacting the articles on another conveyor run.

[0045] There is a baffle or divider plate located under the top conveyor belt (or in certain embodiments, below the top run of the conveyor) so that the cryogen gas flow cannot short circuit back to the inlet of the blower through the conveyor belt.

[0046] This divider plate helps to define the gas circulation path, and allows for a constant gas flow profile to be established across both the top and bottom belts. Alternatively, the gas circulation path can be directed across a lower conveyor run with a return path across the upper conveyor run.

[0047] The overall height of the roof of the crusting freezer is minimized, providing for clearance of the articles transported on the conveyor but not requiring room for a blower or fan above the conveyor, so that the cross sectional area of gas flow is also minimized.

[0048] The floor panel of the freezer is also located within very close proximity to the bottom conveyor return belt for the same reason. This allows the total volumetric flow of gas to be reduced while still achieving high gas flow velocities on the surface of the product.

[0049] Data has shown that for the present embodiments, a 1/4 inch (0.635 cm) crust depth can be achieved in one minute to 1.5 minutes depending on initial log temperature using this configuration. In contrast, conventional tunnel solutions require six minutes to eight minutes to achieve the same crust depth and require ten times to twelve times the tunnel length.

Brief description of the drawings

[0050] For a more complete understanding of the present embodiment disclosures and as already discussed above, there are several options to embody as well as to improve the teaching of the present invention in an advantageous manner. To this aim, reference may be made to the claims dependent on claim 1 as well as on claim 7; further improvements, features and advantages of the present invention are explained below in more detail with reference to particular and preferred embodiments by way of non-limiting example and to the appended drawing figures taken in conjunction with the following description of exemplary embodiments, of which:

FIG. 1 is an elevational, cross sectional end view across the width of an embodiment of a crust freezing apparatus according to the present invention, said apparatus working according to the method of the present invention;

FIG. 2 is an elevational, cross sectional side view across the length of an embodiment of a crust freezing apparatus according to the present invention, said apparatus working according to the method of the present invention;

FIG. 3 is a top perspective view of an embodiment of a crust freezing apparatus according to the present invention, said apparatus working according to the method of the present invention;

FIG. 4 is an elevational side view, partly in cross section, across the length of an alternative embodiment of a crust freezing apparatus according to the present invention, said apparatus working according to the method of the present invention; and

FIG. 5 is a graphical representation of average frozen crust depth (= axis of ordinates, in inches) versus residence time or retention time (= axis of abscissae, in minutes) for exemplary food product embodiments of the method according to the present invention.

[0051] The accompanying drawings are included to provide a further understanding of the apparatus and method(s) provided herein and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the apparatus and method(s) provided herein and, together with the description, serve to explain the principles described herein but are not intended to limit the specification or any of the claims. In the accompanying drawings, like equipment is labelled with the same reference numerals throughout the description of FIG. 1 to FIG. 5.

Detailed description of the drawings;

best way of embodying the present invention

[0052] Before explaining the present inventive embodiment in detail, it is to be understood that the embodiment is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawing, since the present invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

[0053] In the following description, terms such a horizontal, upright, vertical, above, below, beneath and the like, are used solely for the purpose of clarity illustrating the present invention and should not be taken as words of limitation. The drawings are for the purpose of illustrating the present invention and are not intended to be to scale.

[0054] In particular and referring to FIG. 1 to FIG. 3, there is shown a crust freezer embodiment including an apparatus 10 for crust freezing articles 12 on a plurality of conveyor paths 14, 16 comprising an enclosure 20 having a ceiling 22, a floor 24 and a plurality of sidewalls 26, at least one conveyor 18 for transporting the articles 12 through the enclosure 20 and defining at least a first transport path 14 and a second transport path 16, a cryogen gas supply 29, optionally in communication with a sprayer 32 for releasing cryogen 33 into the enclosure, at least one gas circulation device, such as a blower 30, positioned for circulating cryogen gas along a gas circulation path (shown by arrows) 34 across short axes 19 of the first transport path 14 and of the second transport path 16 along the conveyor 18, a divider plate 28 positioned between the first transport path 14 and the second transport path 16, and further defining the gas circulation path 34 whereby the cryogen gas from the gas circulation device 30 passes across articles 12 on the first transport path 14 and returns to the gas circulation device 30, passing across articles 12 on the second transport path 16.

[0055] The first transport path 14 and the second transport path 16 are defined by a plurality of independent conveyors 18, and the divider plate 28 is positioned between the conveyors 18, or between runs of the conveyor 18 which is proximate to the outlet of the blower 30, i.e. at the beginning of the gas circulation path 34.

[0056] The first transport path 14 is designed and configured to transport the articles 12 from an entrance sidewall 46 to an exit sidewall 48 on a first conveyor 18 and the second transport path 16 is designed and configured to transport the articles 12 from the entrance sidewall 46 to the exit sidewall 48 on a second conveyor 18.

[0057] Alternatively, as shown in FIG. 4, the first transport path 14 and the second transport path 16 are defined by an upper and a lower run of a conveyor 18, and the divider plate 28 is positioned between the runs 14, 16 of the conveyor 18.

[0058] The first transport path 14 is designed and configured to transport the articles 12 from a front entrance sidewall 46 to an exit sidewall 48 on a feed run of the conveyor 18, and the second transport path 16 is designed and configured to transport the articles 12 on a return run of the conveyor 18 from an entrance 56 to an exit 58 on a lateral sidewall.

[0059] The articles 12 may be provided to the freezer 10 on an external feed conveyor 60, and the crust frozen articles 12 may be removed from the freezer 10 via an external exit conveyor 62.

[0060] In either of the above embodiments, the gas circulation path 34 is substantially perpendicular to the first transport path 14 and to the second transport path 16, i.e. at about a right angle to the direction of the transport of articles 12 through the freezer 10.

[0061] The gas velocity of the cryogen gas in the gas circulation path 34 may be between about twenty meters per second and about thirty meters per second. Surface convective heat transfer from the articles increases linearly with gas cross velocity.

[0062] In the above-disclosed embodiments, the gas circulation device may be a centrifugal blower 30 positioned laterally with respect to the at least one conveyor 18, in typical embodiments a plurality of inline centrifugal blowers positioned laterally with respect to the conveyor or conveyors 18.

[0063] The blower 30 typically has an impeller 35 driven by a blower motor 36 mounted at the ceiling 22 of the freezer 10, such that gas exits the impeller 35, travels along the gas circulation path 34 across articles 12 on the conveyor 18, and returns to the blower inlet 38.

[0064] In FIG. 2, the line of centrifugal blowers 30 is shown laterally in front of the conveyor 18, and in FIG. 4, the line of centrifugal blowers 30 is shown laterally behind the conveyor 18.

[0065] The conveyor(s) 18 is/are adapted to receive and transport generally cylindrically shaped food logs with the longitudinal axis of the food logs in the direction of the short axis 19 of the conveyor 18; or in other words with the longitudinal axis of each of the food logs being positioned transverse to a direction of movement of the conveyor 18, as shown in FIG. 3.

[0066] There is also provided a method of crust freezing cylindrically shaped articles 12 in a freezer 10 comprising transporting a first portion of articles 12 along a first transport path 14, and a second portion of articles 12 along a second transport path 16 within the freezer 10, establishing a cryogen gas circulation path 34 from at least one gas circulation device 30 across the short axes 19 of the first transport path 14 and of the second transport path 16, whereby cryogen gas from the gas circulation device 30 passes across the first portion of articles 12 on the first transport path 14 and returns to the gas circulation device 30 by passing across articles 12 on the second transport path 16.

[0067] The method may include isolating the gas circulation path 34 across articles 12 on the first transport path 14 from the gas circulation path 34 across articles 12 on the second transport path 16. As disclosed above, in certain embodiments the first transport path 14 and the second transport path 16 are defined by a plurality of independent conveyors 18, and a gas impermeable barrier 28 is positioned between the conveyors 18, or between runs of the conveyor 18 proximate to the exit of the blower 30, or impeller 35.

[0068] In such embodiments, the method includes transporting the first portion of the articles 12 along the first transport path 14 from an entrance sidewall 46 to an exit sidewall 48 of the freezer 10 on a first conveyor 18 and transporting the second portion of the articles 12 along the second transport path 16 from the entrance sidewall 46 to the exit sidewall 48 of the freezer 10 on a second conveyor 18.

[0069] In alternative embodiments of the method, the first transport path 14 and the second transport path 16 are defined by an upper and a lower run of a conveyor 18, and a gas impermeable barrier 28 is positioned between the runs of the conveyor 18.

[0070] In such embodiments of the method, there is included transporting the first portion of the articles 12 along the first transport path 14 from a front entrance sidewall 46 to an exit sidewall 48 in the freezer 10 on a feed run of the conveyor 18, and transporting the second portion of the articles 12 along the second transport path 16 on a return run of the conveyor 18 from an entrance 56 to an exit 58 on a lateral sidewall of the freezer 10.

[0071] In the above-disclosed embodiments of the method, the conveyor or conveyors 18 may receive and transport cylindrically shaped food logs 12 with the longitudinal axis of the food logs 12 in the direction of the short axis 19 of the conveyor 18; or in other words with the longitudinal axis of each of the food logs 12 being positioned transverse to a direction of movement of the conveyor 18.

[0072] FIG. 5 shows a graphical representation of the average crust depth (= axis of ordinates, in inches) versus the residence time or retention time (= axis of abscissae, in minutes) for exemplary food product embodiments according to the above-disclosed method embodiments.

[0073] The following examples are set forth merely to further illustrate the subject method and apparatus for crust freezing articles on multiple conveyor paths. The illustrative examples should not be construed as limiting the subject matter in any manner.

Examples 1 to 12:

[0074] Various deli logs or loaves were crust frozen according to the subject method in a cross flow freezer apparatus at a set point operating temperature of minus 80°F (minus 62°C), at residence or retention times of one, two or three minutes in the freezer. Results are reported in table 1. The crust or surface temperature and the core temperature of the logs were measured before (T1) and after (T2) crust freezing, and the depth of the crust was measured after freezing.

Table 1 for cross flow freezer at minus 80°F (minus 62°C):

ex	residence time or retention time [minutes]	product description	T1 crust [°F/°C]	T1 core [°F/°C]	crust depth [inch]	crust depth [cm]	T2 crust [°F/°C]	T2core [°F/°C]
1	1	all-meat bologna	29/-1.67	24.6/-4.11	0.13	0.33	20/-6.67	25/-3.89
2	2	all-meat bologna	29/-1.67	24.6/-4.11	0.26	0.66	18/-7.78	25/-3.89
3	3	all-meat bologna	29/-1.67	26.2/-3.22	0.36	0.914	16/-8.89	26.1/-3.28
4	1	turkey	30/-1.11	27.6/-2.44	0.14	0.356	20.5/-6.39	27.6/-2.44
5	2	turkey	30/-1.11	27.6/-2.44	0.28	0.711	20.5/-6.39	27.6/-2.44
6	3	turkey	30/-1.11	26.1/-3.28	0.42	1.067	20.5/-6.39	26.1/-3.28
7	1	ham	33.5/0.83	30.1/-1.06	0.10	0.254	19/-7.22	30.1/-1.06
8	2	ham	33.5/0.83	30.1/-1.06	0.20	0.508	19/-7.22	30.1/-1.06
9	3	ham	33.5/0.83	30.1/-1.06	0.30	0.762	19/-7.22	30.1/-1.06
10	1	pimiento loaf	28/-2.22	25/-3.89	0.16	0.406	21.5/-5.83	26/-3.33
11	2	pimiento loaf	28/-2.22	26/-3.33	0.27	0.686	18/-7.78	26/-3.33
12	3	pimiento loaf	28/-2.22	26/-3.33	0.40	1.016	18/-7.78	26/-3.33

Examples 13 to 19:

[0075] Various deli logs or loaves were crust frozen according to the subject method in a cross flow freezer apparatus at a set point operating temperature of minus 80°F (minus 62°C), at a residence or retention time of one minute in the freezer. Results are reported in table 2. The crust and surface temperature and the core temperature of the logs were measured before and after crust freezing, and the depth of the crust was measured after freezing. The crust depths ranged between 0.12 inches and 0.25 inches (between 0.305 cm and 0.635 cm), for an average crust depth of 0.18 inches (0.457 cm).

Table 2 for cross flow freezer at minus 80°F (minus 62°C) with one minute residence or retention time:

		prior to freezing (T1)		after freezing (T2)				
ex	product	surface temp [°F / °C]	core temp [°F / °C]	surface temp [°F / °C]	core temp [°F / °C]	crust depth [inch]	crust depth [cm]	crust temp [°F / °C]
13	oven roasted turkey breast, white meat	38.7/3.72	38.2/3.44	27.4/-2.56	36.2/2.33	0.12	0.305	27.4/-2.56

(continued)

		prior to freezing (T1)		after freezing (T2)				
ex	product	surface temp [°F / °C]	core temp [°F / °C]	surface temp [°F / °C]	core temp [°F / °C]	crust depth [inch]	crust depth [cm]	crust temp [°F / °C]
14	lean oven roasted turkey breast	37.6/3.11	35.3/1.83	17.8/-7.89	32.9/0.5	0.19	0.483	27.3/-2.61
15	old-fashioned loaf	37.8/3.22	34.5/1.39		33.6/0.89	0.156	0.396	28.1/-2.17
16	old-fashioned loaf	33.9/1.06	30.2/-1		30.7/-0.72	0.156	0.396	26/-3.33
17	pickle and pimiento loaf	34.1/1.17	36.9/2.72	19.9/-6.72		0.25	0.635	
18	pickle and pimiento loaf	36.3/2.39	35.3/1.83		34.4/1.33	0.25	0.635	27.4/-2.56
19	olive loaf	28/-2.22	25/-3.89	14/-10	26/-3.33	0.137	0.348	21.5/-5.83

Examples 20 to 29:

[0076] Various deli logs or loaves were crust frozen according to the subject method in a cross flow freezer apparatus at a set point operating temperature of minus 80°F (minus 62°C) (except for example 29 where the freezing temperature was minus 85°F (minus 65°C)), at a residence or retention time of two minutes in the freezer. Results are reported in table 3. The crust and surface temperature and the core temperature of the logs were measured before and after crust freezing, and the depth of the crust was measured after freezing. The crust depths ranged between 0.17 inches and 0.3 inches (between 0.432 cm and 0.762 cm), for an average crust depth of 0.25 inches (0.635 cm).

Table 3 for cross flow freezer at minus 80°F (minus 62°C) with two minutes residence or retention time:

		prior to freezing (T1)		after freezing (T2)				
ex	product	surface temp [°F/ °C]	core temp [°F/°C]	surface temp [°F/ °C]	core temp [°F/°C]	crust depth [inch]	crust depth [cm]	crust temp [°F/°C]
20	slender-sliced beef	38.8/3.78	40/4.44		38/3.33	0.25	0.635	19.6/-6.89
21	slender-sliced beef	38.8/3.78	40/4.44		36.1/2.28	0.25	0.635	25.8/-3.44
22	slender-sliced beef	38.2/3.44	37.8/322		38.1/3.39	0.25	0.635	9.4/-12.56
23	cooked ham	33.1/0.61	30.8/-0.67	19.5/-6.94	39.8/4.33	0.31	0.787	22.8/-5.11
24	oven roasted turkey breast, white meat	39.8/4.33	39.7/4.28	25.2/-3.78	37.2/2.89	0.17	0.432	25.3/-3.72
25	lean oven roasted turkey breast	36.9/2.72	33.9/1.06	17.9/-7.83	32.9/0.5	0.25	0.635	23.5/-4.72
26	all-meat bologna	29/-1.67	24.6/-4.11	15/-9.44	25/-3.89	0.25	0.635	18/-7.78
27	olive loaf	28/-2.22	26/-3.33	18/-7.78	26/-3.33	0.23	0.635	18/-7.78
28	turkey	30/-1.11	27.6/-2.44	14/-10	27.6/-2.44	0.2	0.508	20.5/-6.39

(continued)

		prior to freezing (T1)		after freezing (T2)				
ex	product	surface temp [°F/°C]	core temp [°F/°C]	surface temp [°F/°C]	core temp [°F/°C]	crust depth [inch]	crust depth [cm]	crust temp [°F/°C]
29	turkey	30/-1.11	26.1/-3.28	13/-10.56	26.1/-3.28	0.375	0.953	20.5/-6.39

Examples 30 to 34:

[0077] Various deli logs or loaves were crust frozen according to the subject method in a cross flow freezer apparatus at a set point operating temperature of minus 80°F (minus 62°C), at a residence or retention time of three minutes in the freezer. Results are reported in table 4. The crust or surface temperature and the core temperature of the logs were measured before and after crust freezing, and the depth of the crust was measured after freezing. The crust depths ranged between 0.24 inches and 0.4 inches (between 0.61 cm and 1.016 cm), for an average crust depth of 0.31 inches (0.787 cm).

Table 4 for cross flow freezer at minus 80°F (minus 62°C) with three minutes residence or retention time:

		prior to freezing (T1)		after freezing (T2)				
ex	product	surface temp [°F/°C]	core temp [°F/°C]	surface temp [°F/°C]	core temp [°F/°C]	crust depth [inch]	crust depth [cm]	crust temp [°F/°C]
30	slender-sliced beef	38.6/3.67	39.1/3.94		38.6/3.67	0.31	0.787	7.2/-13.78
31	cooked ham	33.4/0.78	31/-0.56	10.9/-11.72	29.8/-1.22	0.26	0.66	22.9/-5.06
32	oven roasted turkey breast, white meat	40.1/4.5	39.9/4.39	23.5/-4.72	37.9/3.28	0.24	0.61	24/-4.44
33	lean oven roasted turkey breast	34.7/1.5	32.5/0.28	15.9/-8.94	30.6/-0.78	0.34	0.864	22.6/-5.22
34	all-meat bologna	29 /-1.67	26.2/-3.22	11/-11.67	26.1/-3.28	0.406	1.031	16/-8.89

[0078] The ranges and averages of crusting depths across a variety of products at residence or retention times of one, two and three minutes, are reported in table 5. It should be understood that the product crust depth and crust temperature is not only a function of the residence time of the product in the cross flow freezer, but also a function of the type of product (, i.e. the type of meat and how it was prepared), and also the initial temperature of the product entering the freezer. While achieving a crust depth of about 0.25 inches (about 0.635 cm) is desirable to promote efficient slicing and high yields of most food products, for many food products a shallower crust depth provides beneficial slicing efficiencies and yields.

[0079] The data demonstrates that the subject cross flow method and apparatus results in the achievement of acceptable and desirable crust depths at a fraction of the residence or retention time needed in a conventional cryogenic freezer, typically six minutes to eight minutes.

Table 5:

residence time or retention time (minutes)	average crust depth [inch]	average crust depth [cm]	depth range [inch]	depth range [cm]
0	0	0	0	0
1	0.18	0.457	0.12 to 0.25	0.305 to 0.635

(continued)

residence time or retention time (minutes)	average crust depth [inch]	average crust depth [cm]	depth range [inch]	depth range [cm]
2	0.25	0.635	0.17 to 0.3	0.432 to 0.762
3	0.31	0.787	0.24 to 0.4	0.61 to 1.016

[0080] The performance of the subject cross flow apparatus and method has also been shown to be superior to a more rigorous freezer environment, that of an impingement freezer, in which solid or liquid cryogen is entrained in a cryogenic gas to impinge upon product as it is transported through the freezer.

[0081] As shown in table 6, the heat transfer coefficient for the subject cross flow freezer at a set point operating temperature of minus 80°F (minus 62°C), in a crusting operation for all-meat bologna logs was an average of 18.3 Btu/(hr*ft^2*°F) (being 103.91 W/(m^2*K)) as compared to an average of only 11.9 Btu/(hr*ft^2*°F) (being 67.57 W/(m^2*K)) for an impingement freezer at a set point operating temperature of minus 85°F to minus 90°F (minus 65°C to minus 68°C).

[0082] The bologna logs were 39 lbs each (17.69 kg each), with a diameter of 4.35 inches (11.05 cm), a length of 70 inches (1.78 m), a surface area of 956.13 in^2 (0.62 m^2), and a density of 64.8 lb/ft^3 (1038.10 kg/m^3).

[0083] The latent heat was 79 Btu/lb (183.75 kJ/kg), and the freeze point was 28°F (minus 1.7°C).

Table 6, comparison between crossflow and impingement freezer:

cross flow											
freezer SP [°F/°C]	retention time [minutes]	T1 crust [°F/°C]	T1 core [°F/°C]	crust depth [inch]	crust depth [cm]	T2 crust [°F/°C]	T2 core [°F/°C]	mass of product frozen [lb/kg]	heat removal crust [Btu/lb/ kJ/kg]	Tlm [°F]	heat transfer coefficient [Btu/ (hr*ft^2*°F)/ W/ (m^2*K)]
-80/-62.22	2	29/-1.67	24.6/-4.11	0.25	0.635	18/-7.78	25/-3.89	9.0/4.1	42.8/99.5	103.4	16.8/95.40
-80/-62.22	3	29/-1.67	262/-3.22	0.406	1.031	16/-8.89	26.1/-3.89	14.6/6.6	46.1/107.2	102.4	19.8/112.43
									average =		18.3/103.91
impingement											
freezer SP [°F/°C]	retention Time [minutes]	T1 crust [°F/°C]	T1 core [°F/°C]	crust depth [inch]	crust depth [cm]	T2 crust [°F/°C]	T2 core [°F/°C]	mass of product frozen [lb/kg]	heat removal crust [Btu/lb / kJ/kg]	Tlm [°F]	heat transfer coefficient [Btu/ (hr*ft^2*°F)/ W/ (m^2*K)]
-85/-65	2	39/3.89	38/3.33	0.25	0.635	23/-5	38/3.33	9.0/4.1	39.9/92.8	115.8	14.0/79.50
-90/-67.78	2	39/3.89	38/3.33	0.23	0.584	235/4.72	38/3.33	8.2/3.7	37.7/87.7	121.1	11.6/65.87
-85/-65	2	41.1/5.06	38/3.33	0.25	0.635	24/-4.44	38/3.33	9.0/4.1	37.2/86.5	117.3	12.8/72.68
-90/-67.78	2	28/-2.22	24/-4.44	0.24	0.61	23/-5	24/4.44	8.6/3.9	27.0/62.0	115.5	9.1/51.67
									average =		11.9/67.57

[0084] It will be understood that the embodiments described herein are merely exemplary, and that one skilled in the art may make variations and modifications without departing from the spirit and scope of the present invention. All such variations and modifications are intended to be included within the scope of the present invention as described and claimed herein. Further, all embodiments disclosed are not necessarily in the alternative, as various embodiments of the present invention may be combined to provide the desired result.

List of reference signs

[0085]

10 apparatus, in particular cooling apparatus or freezing apparatus, for example crust freezer apparatus
12 article, in particular cylindrically shaped article, for example cylindrically shaped food article or food log
14 first path, in particular first transport path, for example upper run, of conveyor 18
16 second path, in particular second transport path, for example lower run, of conveyor 18
18 conveyor
19 short axis of conveyor 18, in particular of first transport path 14 and/or of second transport path 16
20 enclosure
22 ceiling
24 floor
26 sidewall
28 gas impermeable barrier, in particular divider, for example divider plate, between first transport path 14 and second transport path 16
29 cryogen gas supply
30 gas circulation device, in particular blower, for example centrifugal blower
32 sprayer for releasing cryogenic substance or coolant 33 into enclosure 20
33 cryogenic substance or coolant, in particular cryogen gas
34 gas circulation path, in particular cryogen gas circulation path
35 impeller of gas circulation device 30
36 motor for driving gas circulation device 30
38 inlet of gas circulation device 30
46 entrance sidewall, in particular front entrance sidewall, of a first conveyor 18
48 exit sidewall of a first conveyor 18
56 entrance sidewall, in particular lateral entrance sidewall, of a second conveyor 18
58 exit sidewall, in particular lateral exit sidewall, of a second conveyor 18
60 external feed conveyor
62 external exit conveyor

Claims

1. An apparatus (10) for crust freezing articles (12), in particular cylindrically shaped articles, for example cylindrically shaped food articles or food logs, on multiple transport paths (14, 16) of at least one conveyor (18), comprising:

- an enclosure (20) having a ceiling (22), a floor (24) and a plurality of sidewalls (26),
- the at least one conveyor (18) for transporting the articles (12) through the enclosure (20) and defining at least the first transport path (14) and the second transport path (16),
- a cryogen gas supply (29),
- at least one gas circulation device (30) positioned for circulating cryogen gas (33) along a gas circulation path (34), in particular along a cryogen gas circulation path, across short axes (19) of the first transport path (14) and of the second transport path (16), said gas circulation device (30) in particular comprising a centrifugal blower, for example a plurality of inline centrifugal blowers, positioned laterally to the at least one conveyor (18),
- a gas impermeable barrier (28), in particular a divider, for example a divider plate, positioned between the first transport path (14) and the second transport path (16), and defining the gas circulation path (34) whereby the cryogen gas (33) passes across the articles (12) on the first transport path (14) and returns to the gas circulation device (30) passing across the articles (12) on the second transport path (16), said gas circulation path (34) in particular being substantially perpendicular to the first transport path (14) and to the second transport path (16).

2. The apparatus according to claim 1, wherein the first transport path (14) and the second transport path (16) are defined by a plurality of independent conveyors (18), and the gas impermeable barrier (28) is positioned between the independent conveyors (18).

3. The apparatus according to claim 2, wherein the first transport path (14) is configured to transport the articles (12) from an entrance sidewall (46) to an exit sidewall (48) on a first conveyor (18), and the second transport path (16) is configured to transport the articles (12) from an entrance sidewall (56) to an exit sidewall (58) on a second conveyor (18).

4. The apparatus according to claim 1, wherein the first transport path (14) and the second transport path (16) are defined by an upper run of a conveyor (18) and by a lower run of the conveyor (18), and the gas impermeable barrier (28) is positioned between the upper run and the lower run.

5. The apparatus according to claim 4, wherein the first transport path (14) is configured to transport the articles (12) from a front entrance sidewall (46) to an exit sidewall (48) on a feed run of the conveyor (18), and the second transport path (16) is configured to transport the articles (12) on a return run of the conveyor (18) from an entrance (56) to an exit (58) on a lateral sidewall.

6. The apparatus according to at least one of claims 1 to 5, wherein the at least one conveyor (18) is adapted to receive and transport the articles (12) with a longitudinal axis of each of the articles (12) positioned in a direction similar to a direction of the short axis (19) of the conveyor (18).

7. A method of crust freezing articles (12), in particular cylindrically shaped articles, for example cylindrically shaped food articles or food logs, in a freezing apparatus (10), comprising:

- transporting a first portion of the articles (12) along a first transport path (14), and a second portion of the articles (12) along a second transport path (16) within the freezing apparatus (10),
- establishing a gas circulation path (34), in particular a cryogen gas circulation path, from at least one gas circulation device (30) across short axes (19) of the first transport path (14) and of the second transport path (16), whereby cryogen gas (33) from the gas circulation device (30) passes across the first portion of the articles (12) on the first transport path (14) and returns to the gas circulation device (30) by passing across the articles (12) on the second transport path (16), said gas circulation path (34) in particular established substantially perpendicular to the first transport path (14) and to the second transport path (16).

8. The method according to claim 7, further comprising isolating the gas circulation path (34) across the articles (12) on the first transport path (14) from the gas circulation path (34) across the articles (12) on the second transport path (16).

9. The method according to claim 7 or 8, further comprising defining the first transport path (14) and the second transport path (16) by a plurality of independent conveyors (18), wherein a gas impermeable barrier (28), in particular a divider, for example a divider plate, is positioned between the independent conveyors (18).

10. The method according to claim 9, further comprising transporting the first portion of the articles (12) along the first transport path (14) from an entrance sidewall (46) to an exit sidewall (48) of the freezing apparatus (10) on a first conveyor (18), and transporting the second portion of the articles (12) along the second transport path (16) from the entrance sidewall (56) to the exit sidewall (58) of the freezing apparatus (10) on a second conveyor (18).

11. The method according to claim 7 or 8, further comprising defining the first transport path (14) and the second transport path (16) by an upper run of the conveyor (18) and by a lower run of a conveyor (18), wherein a gas impermeable barrier (28) is positioned between the upper run and the lower run.

12. The method according to claim 11, further comprising transporting the first portion of the articles (12) along the first transport path (14) from a front entrance sidewall (46) to an exit sidewall (48) in the freezing apparatus (10) on a feed run of the conveyor (18), and transporting the second portion of the articles (12) along the second transport path (16) on a return run of the conveyor (18) from an entrance (56) to an exit (58) on a lateral sidewall of the freezing apparatus (10).

13. The method according to at least one of claims 7 to 12, wherein the gas circulation device (30) comprises a centrifugal blower, in particular a plurality of inline centrifugal blowers, positioned laterally to the at least one conveyor (18).

14. The method according to at least one of claims 7 to 13, further comprising receiving and transporting the articles (12) with a longitudinal axis of each of the articles (12) being in a direction similar to a direction of the short axes (19) of the conveyor (18).

15. The method according to at least one of claims 7 to 14, wherein a gas velocity of the cryogen gas (33) in the gas circulation path (34) is between about twenty meters per second and about thirty meters per second.

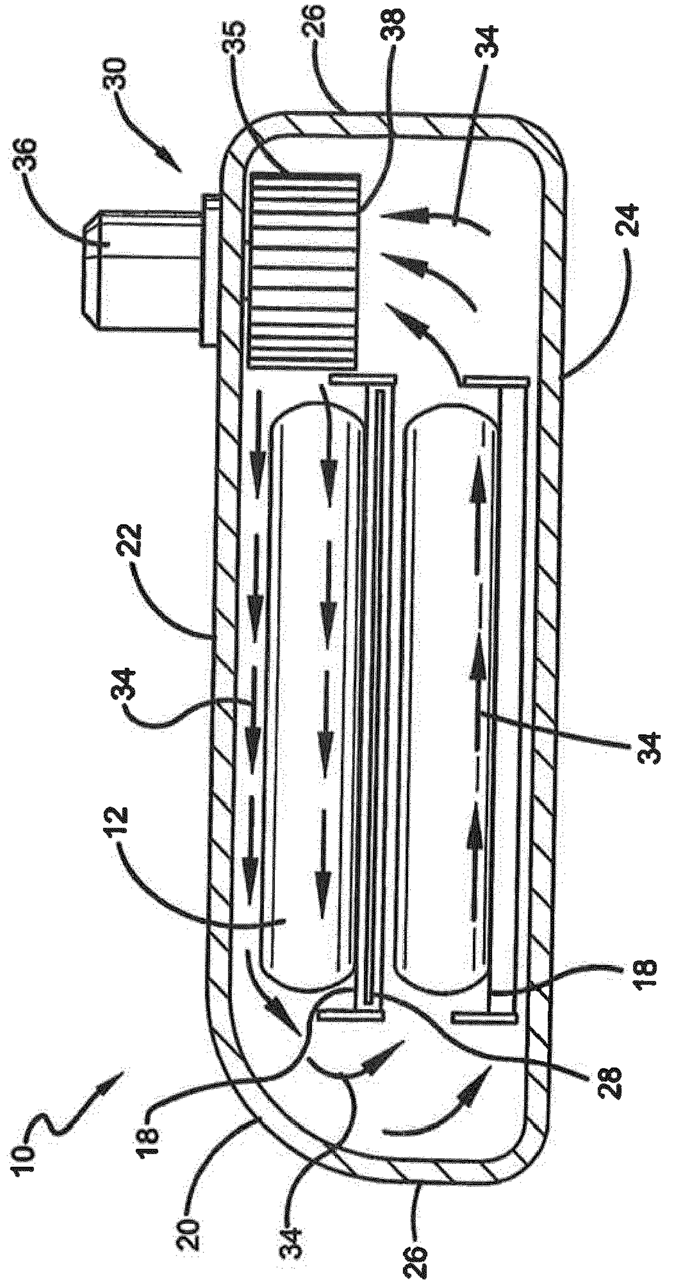

FIG. 1

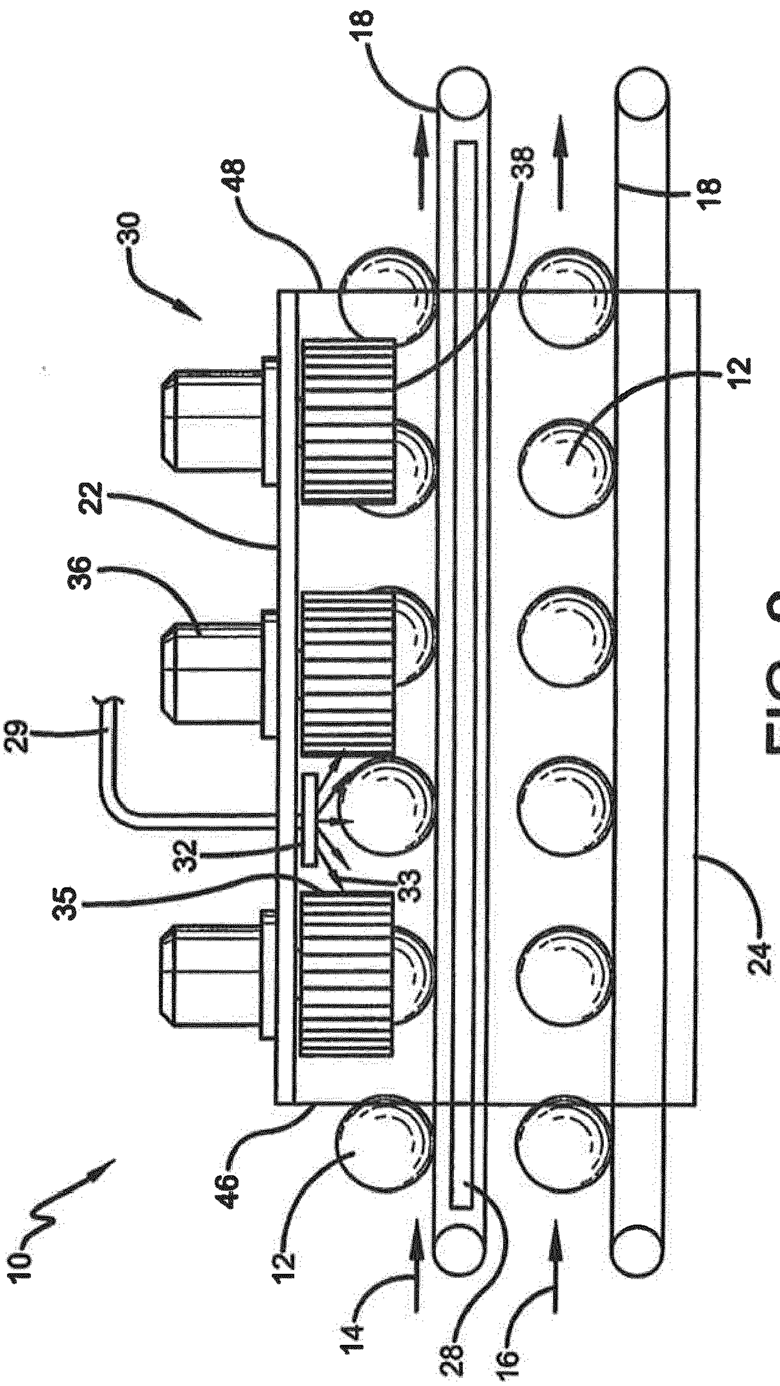

FIG. 2

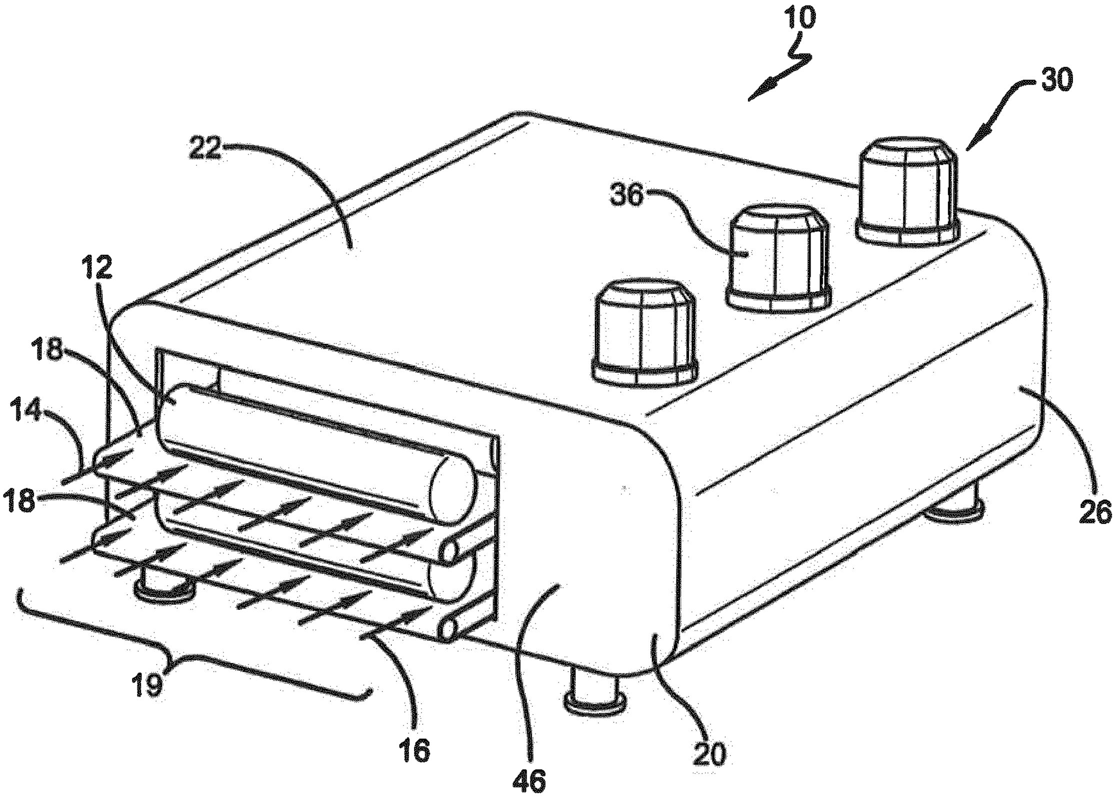

FIG. 3

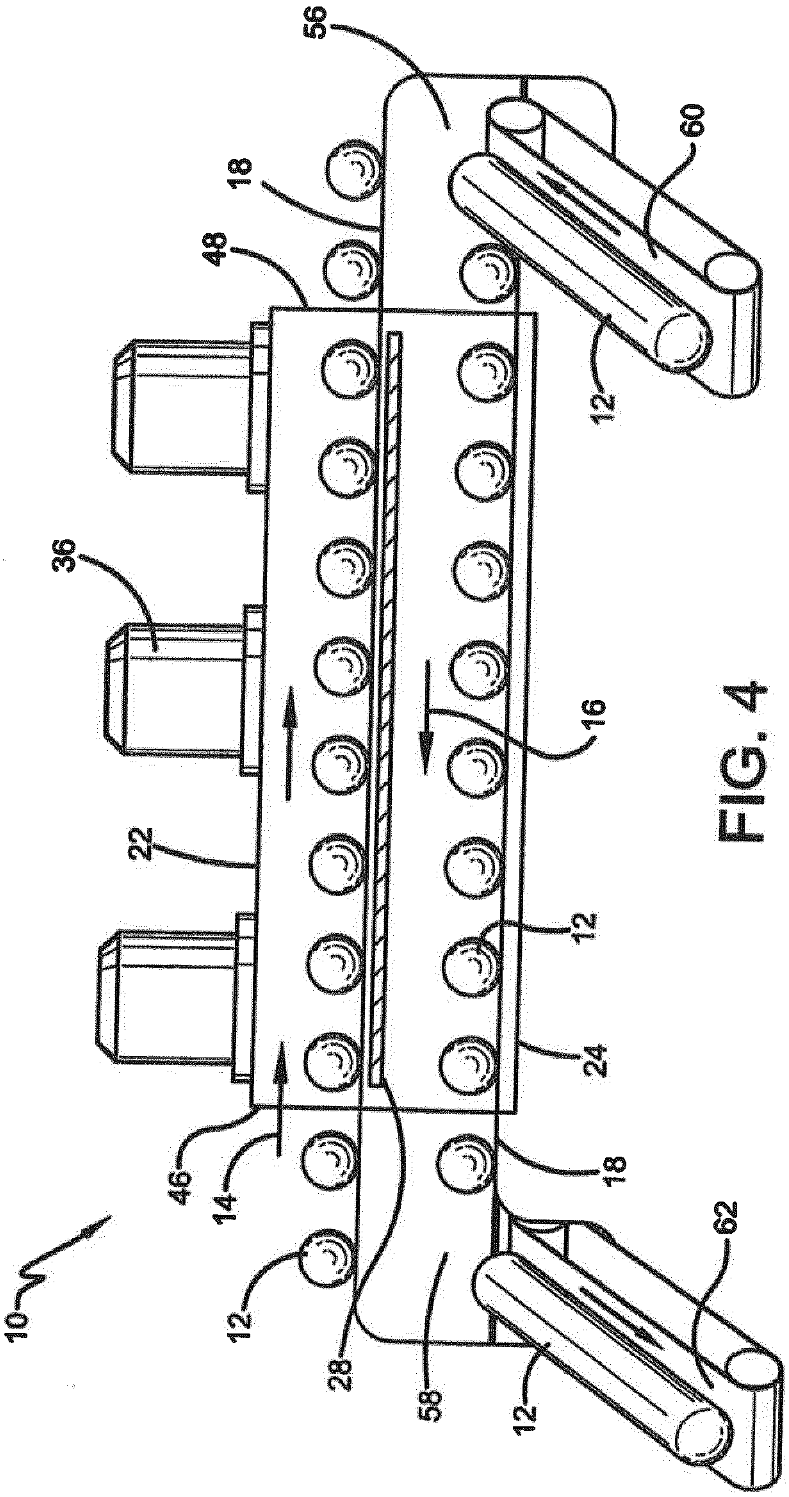

FIG. 4

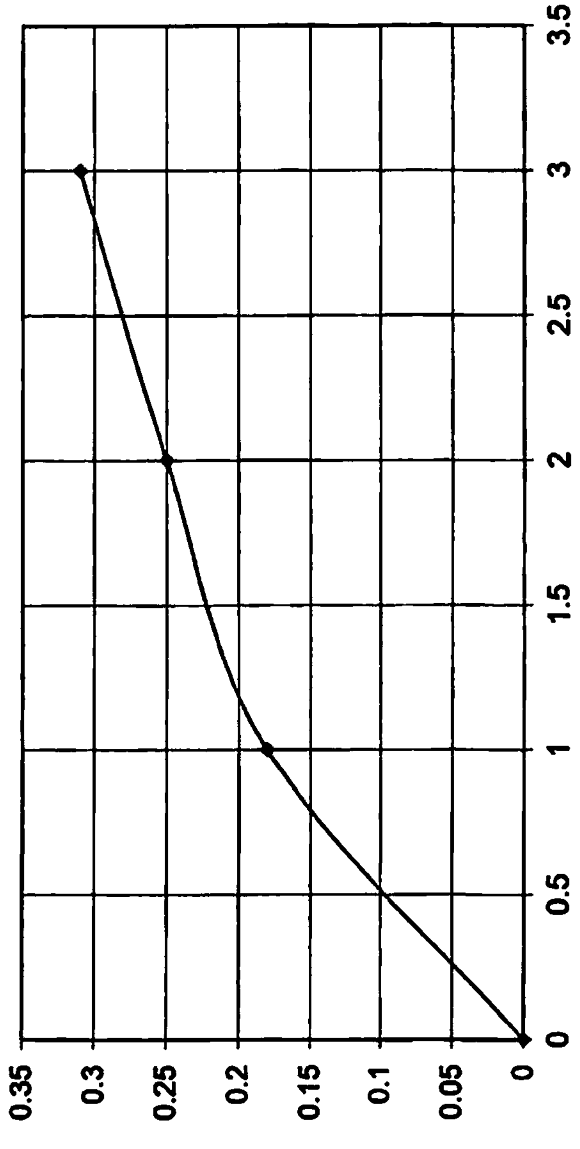

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 17 17 2274

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2012/273165 A1 (MCCORMICK STEPHEN A [US] ET AL) 1 November 2012 (2012-11-01) * paragraphs [0020] - [0028], [0032] - [0054]; figures 1-4 *	1,4,6-8, 11,13-15	INV. F25D13/06 F25D3/11 F25D3/12
X	US 3 708 995 A (BERG D) 9 January 1973 (1973-01-09)	7,9,10, 12,14,15	
Y	* figures 1-4 *	1-6,8, 11,13	
Y	US 2010/319365 A1 (NEWMAN MICHAEL D [US]) 23 December 2010 (2010-12-23) * paragraphs [0012] - [0019], [0037]; figure 5 *	1-6,8, 11,13	

TECHNICAL FIELDS SEARCHED (IPC)

F25D
A23B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	15 November 2017	Léandre, Arnaud

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15-11-2017

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