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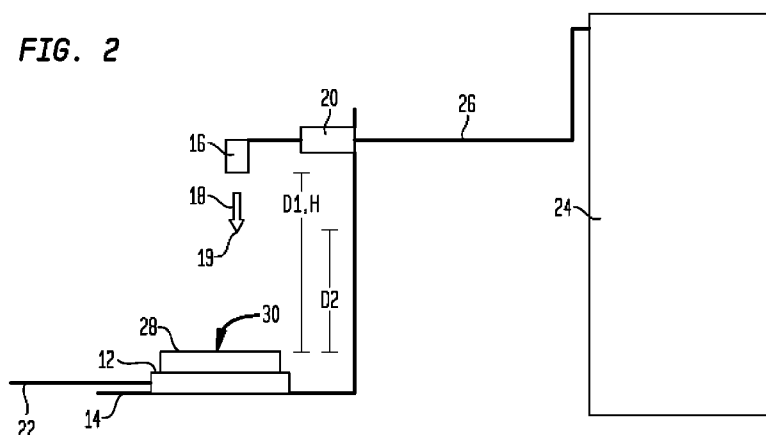
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FIG. 2



(57) Abstract: In order to overcome the limitations and problems that earlier apparatus and methods for determining physiological effects of heat flux with a cryogenic substance applied to an organism have experienced, it is proposed that the apparatus (10) comprises: - a heat flux sensor (12); - a cryogen delivery apparatus (16) spaced apart a distance (D1) from the heat flux sensor (12); and - at least one organism culture (28) supported on the heat flux sensor (12) in a path of delivery of the cryogenic substance from the cryogen delivery apparatus (16) to contact the at least one organism culture (28). The corresponding method for determining physiological effects of heat flux with a cryogenic substance applied to an organism comprises: - testing at least one organism culture (28) for heat flux with a cryogenic substance; and - establishing an amount of heat transfer required at the organism for achieving maximum destruction of said organism.

APPARATUS AND METHOD TO DETERMINE PHYSIOLOGICAL EFFECTS OF HEAT FLUX WITH CRYOGEN APPLIED TO ORGANISMS

Technical field of the present invention

The present invention basically relates to apparatus and methods using cooling to destroy organisms on products.

5 Technological background of the present invention

Every product and every organism has a known rate of cooling and therefore, each product and organism can be preserved or destroyed at an optimum rate of such cooling.

10 In a freezer tunnel for food products for example, process control of heat flux occurring in such tunnel is critical to the operation of same for the most effective and efficient chilling or freezing of the food product. If an organism, such as for example campylobacter, on the food product is to be destroyed it is necessary to know the effect of a cryogen, such as for example a liquid nitrogen (LIN) spray, on the campylobacter in order to control the freezer tunnel operation for using that type of spray.

15 Therefore, by understanding the effect of, for example, a LIN spray on the organism, one would be able to establish whether a particular LIN spray will be able to effectively destroy the organism cell, the method to use for such destruction, how much time is needed to achieve the destruction and how much energy will be required to do so.

20 The above is particularly important for certain food processing facilities such as for example those facilities processing chicken carcass products, wherein a manufacturer wants to preserve the skin on the carcass or body part for the end use customer, but must effectively destroy or kill any organisms on the skin.

25 Disclosure of the present invention: object, solution, advantages

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.

30 These objects are accomplished by an apparatus comprising the features of claim 1 as well as by a method comprising the features of claim 8. Advantageous embodiments and expedient improvements of the present invention are disclosed in the respective dependent claims.

35 The present invention basically provides for improved apparatus and methods to determine physiological effects of heat flux with a cryogen applied to an organism, and in particular to use cryogenics to destroy campylobacter on food products, for example for controlling a freezer.

40 According to the present invention, use of heat flux measurement for temperature control is more accurate and therefore more reliable than using a temperature probe or sensor to determine optimum conditions for destroying organisms.

The present invention includes an apparatus to determine physiological effects of heat flux with a cryogenic substance applied to an organism, which apparatus includes a heat flux sensor; a cryogen delivery apparatus spaced apart a distance from the heat flux sensor; and at least one organism culture supported on the heat flux sensor in a path of delivery of the cryogenic substance from the cryogen delivery apparatus to contact the at least one organism culture.

According to an advantageous embodiment of the present invention, the cryogen delivery apparatus may be movable with respect to the heat flux sensor to alter the delivery path of the cryogenic substance and the distance to the at least one organism culture.

In an expedient embodiment of the present invention, the cryogen delivery apparatus may comprise a spray nozzle, in particular a cone jet.

According to a favoured embodiment of the present invention, the spray nozzle may emit cryogen spray, in particular a cryogen spray cone having a lower most edge at a distance from the heat flux sensor.

In a preferred embodiment of the present invention, the cryogenic substance may be a cryogen selected from the group consisting of liquid nitrogen (LIN), liquid oxygen (LOX), and liquid argon.

According to an advantageous embodiment of the present invention, the at least one organism culture may comprise campylobacter.

In an expedient embodiment of the present invention, the apparatus may further include a source of cryogen in fluid communication with the cryogen delivery apparatus.

There is also provided herein a related method to determine physiological effects of cryogen on an organism, more particularly of heat flux with a cryogenic substance applied to the organism, which method includes testing at least one live organism culture for heat flux with a cryogenic substance for establishing an amount of heat transfer required at the organism for achieving maximum destruction of said organism.

According to a favoured embodiment of the present invention, the testing may further comprise spraying the cryogenic substance onto the organism for different periods of time.

In a preferred embodiment of the present invention, the cryogenic substance may be a cryogen selected from the group consisting of liquid nitrogen (LIN), liquid oxygen (LOX), and liquid argon.

According to an advantageous embodiment of the present invention, the testing may comprise contacting the at least one organism culture with the cryogenic substance; observing structural integrity of cells of the at least one organism culture; adjusting a distance that the cryogenic substance travels for contacting the at least one organism culture; adjusting an amount of the cryogenic substance applied to the at least one organism culture; adjusting an amount of time the cryogenic substance is applied to the at least one organism culture; and adjusting an amount of heat transfer which occurs from subjecting the at least one organism culture to the cryogenic substance.

In an expedient embodiment of the present invention, the observing may comprise measuring adenosine

triphosphate (ATP) leaking from cell walls of the organism.

According to a favoured embodiment of the present invention, the adjusting the amount of the cryogenic substance may comprise emitting the cryogenic substance in a cone shape for covering the at least one organism culture.

In a preferred embodiment of the present invention, the at least one organism culture comprises campylobacter.

According to an advantageous embodiment of the present invention, the testing is with a plurality of organism cultures.

Brief description of the drawing

For a more complete understanding of the present inventive 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 and on claim 8; further improvements, features and advantages of the present invention are explained below in more detail with reference to the following description of preferred embodiments by way of non-limiting example and to the appended drawing figures taken in conjunction with the description of the embodiments, of which:

FIG. 1 shows a schematic of a spray apparatus embodiment of the present invention;

FIG. 2 shows a schematic of the apparatus for testing an organism culture; and

FIG. 3 shows a graph depicting an example of organism destruction by embodiments of the present invention.

In the appended drawing figures, like equipment is labelled with the same reference numerals throughout the description of FIG. 1 to FIG. 3.

Detailed description of the drawings; best way of embodying the present invention

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.

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 invention and should not be taken as words of limitation. The drawings are for the purpose of illustrating the invention and are not intended to be to scale.

Basically, apparatus and method embodiments are provided herein for testing live campylobacter culture with heat flux instrumentation to establish an amount of heat transfer necessary in order to achieve maximum destruction of a campylobacter cell on a cost-effective basis.

The apparatus and method also determine a type of liquid nitrogen (LIN) spray jet required to do so, an amount of time required to destroy the campylobacter, a distance that the LIN spray jet should be from the campylobacter organism, and the LIN pressure required for the LIN spray jet to be provided in an optimum pattern.

Such apparatus and method embodiments clearly establish operational parameters for control of a cooling or freezing tunnel different from known methods of process control.

Referring to FIG. 1, there is shown a spray rig apparatus 10 for testing a physiological effect of cryogen spray on an organism, such as for example a campylobacter organism, in order to determine operational control of a freezer tunnel in which the organism will be exposed for destruction of same. A related method will be discussed hereinafter.

The cryogen used can be liquid nitrogen (LIN), liquid oxygen (LOX) or liquid argon. For purposes of the disclosure herein, LIN will be used by way of example only. LIN and the other cryogen substances provide for rapid heat transfer of the campylobacter and therefore, are efficient and cost-effective in destroying same.

Reference herein to a freezer tunnel is by way of example only, and it is understood that the present embodiments can be used for other types of freezers, such as for example spiral freezers.

The spray rig apparatus 10 or apparatus includes a heat flux sensor 12 supported on a platform 14 or other supporting member, spaced apart from and for most applications beneath a cryogen delivery apparatus 16 such as for example a spray nozzle for producing a related spray 18 of the cryogen to contact the sensor.

A clamp 20 or other mechanical fastener supports the nozzle 16 in position with respect to the heat flux sensor 12. The clamp 20 is adjustable to thereby adjust a direction of the LIN spray 18, especially with respect to the heat flux sensor 12.

The heat flux sensor 12 is connected by a wire 22 to a controller (not shown) for transmitting data to the controller or other C[entral]P[rocessing]U[nit] (not shown).

A tank 24 or vessel as constructed contains therein the cryogen substance such as for example the LIN which is distributed from the tank through a hose 26 in fluid communication with the cryogen spray nozzle 16. The tank 24 may have an internal volume sized to contain for example 200 liters (200L) of the LIN.

The tank 24 is under pressure and the LIN upon exposure to ambient atmosphere at the spray nozzle 16 phase changes to a gaseous liquid spray. The pressure of the LIN through the hose 26 may be at 2 Barg, for example.

Referring now to FIG. 2, the apparatus 10 is shown for use with a campylobacter culture 28 removably mounted on the heat flux sensor 12. The schematic of the apparatus for testing an organism culture is shown with the liquid nitrogen spray, height of a liquid nitrogen spray, and area of liquid nitrogen spray to determine best conditions to destroy most if not all of the organism in the culture.

The campylobacter culture 28 may be contained in a petri dish 30 or any other type of container suitably constructed for containing organism cultures therein. The petri dish 30 is supported on the heat flux sensor 12. A plurality of tests are carried out using the apparatus 10 to determine heat transfer rates of the cultures of

campylobacter which are exposed to the cryogen spray 18.

The purpose of the test apparatus 10 and related method is to determine

- (i) whether the cryogen or in this instance the LIN spray 18 disrupts the campylobacter cells by viewing cell contents to determine if the cell contents have leaked from the cells (which determination can be done with a test to rapidly measure actively growing microorganisms through detection of adenosine triphosphate (ATP) leaking from the cells) after exposure to the LIN spray;
- (ii) an amount of campylobacter destroyed when exposed to the spray 18 over different set points of time such as for example intervals of five seconds or ten seconds from an aggregated period of time from ten seconds to forty seconds;
- (iii) a height H or distance D1 of an outlet of the spray nozzle 16 above the culture 28 (or alternatively a distance D2 of a cone 19 of the spray 18 to the culture 28) to establish a best height and/or distance for maximum effect of the spray 18 on the cultured organism; and
- (iv) an amount of energy – watts per square meter ($= W/m^2$) – of heat transfer which occurs from the spray 18 and how same corresponds to the destruction of the campylobacter organism. The cone shape 19 of the spray 18 facilitates covering the culture 28.

All living organisms have cells, and all cells include therein adenosine triphosphate (ATP). Organisms other than campylobacter can also be tested with the present embodiments. As soon as a cell wall is breached, the ATP will begin leaking out of the cell, and when a certain amount of the ATP has indeed leaked from the cell same will be destroyed. The rapid shock of the heat flux created by the extremely low, cryogenic temperature of the LIN breaches the cell wall causing the ATP to leak from the cell resulting in the destruction of same.

FIG. 3 shows a graph (channel 1) depicting a heat transfer average of 40 mV, wherein the x-axis (abscissa) discloses the amount of time in seconds, while the y-axis (ordinate) discloses an amount of voltage in volts used during the test. An Example follows.

Referring again to FIG. 2, a test for determining the parameters of the LIN spray to be applied to the campylobacter will necessitate using a plurality of the cultures 28 each to be in a respective one of the petri dishes 30 in which a similar amount of the campylobacter culture/organism is provided in each dish. The plurality of dishes 30 are each a "control" as long as each contains essentially the same type and amount of the organism.

Thereafter, each dish is exposed under different conditions provided by the apparatus 10, resulting in a plurality of the petri dishes 30 being subjected to different operating parameters of the apparatus to determine the most effective combination of variables (i) to (iv) discussed above to destroy the organism.

For example, petri dish #1 holding a specific amount of campylobacter culture 28 would be positioned on the heat flux sensor 12 and spray nozzle 16 set at a specific height H from the culture 28. Additionally, the pressure of the cryogen passing through the nozzle 16 would be so that the cone 19 of the cryogen spray would be at a specific distance D2 from the culture. Moreover, the amount of time in seconds would be selected for exposure of the culture 28 to the LIN spray.

After the cryogenic substance (LIN) is applied to the culture 28, the petri dish #1 would be removed from the heat flux sensor 12, identified or captioned with the foregoing testing particulars and stored for comparison after additional petri dishes (petri dish #2, etc.) are placed on the heat flux sensor 12 with a different combination of

height, distance and time.

However, each of the subsequent petri dishes 30 (#2, etc.) would still contain the same type and amount of organism, such as campylobacter used in the petri dish #1. After x-number of campylobacter cultures 28 were tested, all would be compared under a microscope for determining which combination of height, distance, time and LIN spray most effectively destroyed the cultures.

Such combination would be used as the optimum conditions necessary for the food freezer apparatus in order to efficiently destroy the campylobacter on the surface of the food product. A further Example follows.

Example

A campylobacter culture 28 is exposed to a LIN spray 18, which spray is 150 mm from the culture for twenty, thirty, and 42 second periods of time. During the periods of time, the organism will have a 99 % to 99.9 % reduction (i.e. be destroyed) because the organism will suffer from cell wall breakdown caused by exposure to the LIN spray.

Adenosine triphosphate (ATP) leakage from the cell will occur into the surrounding area as the cell wall begins and continues to fail. This substantial destruction in the organism is caused by a cell wall of each failing or breaking down, which causes the ATP to leak from the organism and thereby be detected. The ATP leakage is used to measure the percentage of organism destroyed. ATP is present in all living organisms.

It was determined in this Example that the spray 18 positioned 150 mm distant from the culture 28 required 1938 W/m^2 [$= 3.15 * 615 \text{ BTU}/(\text{hour ft}^2)$], wherein $615 = 0.615 * 1000$ and $0.615 = 4\text{mV} / 6.5$] of continuous spray to enable destruction of the campylobacter organism.

Accordingly, this was determined to be the zone of destruction necessary for campylobacter when processing same in a freezer tunnel that will destroy the organism, thereby better preserving the food product.

Referring still to FIG. 3, an amount of heat transfer is shown occurring at the culture over hundred seconds. It can be seen that the amount of heat transfer is constant indicating that the LIN spray is uniform and continuous. The y-axis displays micro-volts from the heat flux cell, which is converted to W/m^2 , while the x-axis displays the time in seconds. The heat transfer (W/m^2) produced over the time period shown by the graph by the LIN spray is sufficient to destroy the campylobacter, otherwise known as the zone of destruction.

Although the present embodiments have been discussed with respect to the campylobacter organism, it is understood that the present embodiments can be used with other types of organisms and food products in order to establish cooling rates for the optimum preservation of such products or destruction of organisms thereon.

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 invention. All such variations and modifications are intended to be included within the scope of the invention as described and claimed herein. Further, all embodiments disclosed are not necessarily in the alternative, as various embodiments of the invention may be combined to provide the desired result.

List of reference numerals

- 10 apparatus, in particular spray rig apparatus
- 12 heat flux sensor
- 14 platform or other supporting member
- 16 cryogen delivery apparatus, in particular spray nozzle, for example LIN cone jet
- 18 cryogen spray, in particular LIN spray
- 19 cone or cone shape of cryogen spray 18
- 20 clamp or other mechanical fastener, in particular to hold cryogen delivery apparatus 16
- 22 wire
- 24 tank or vessel
- 26 hose, in particular cryogen hose, for example LIN hose
- 28 organism culture, in particular campylobacter culture
- 30 petri dish
- D1 distance between heat flux sensor 12 and cryogen delivery apparatus 16
- D2 distance between heat flux sensor 12 and cone 19, in particular between heat flux sensor 12 and lower most edge of cone 19
- H distance between cryogen delivery apparatus 16 and organism culture 28, in particular height of cryogen delivery apparatus 16 from organism culture 28

Claims

1. An apparatus (10) to determine physiological effects of heat flux with a cryogenic substance applied to an organism, comprising:
 - a heat flux sensor (12);
 - a cryogen delivery apparatus (16) spaced apart a distance (D1) from the heat flux sensor (12); and
 - at least one organism culture (28) supported on the heat flux sensor (12) in a path of delivery of the cryogenic substance from the cryogen delivery apparatus (16) to contact the at least one organism culture (28).
2. The apparatus according to claim 1, wherein the cryogen delivery apparatus (16) is movable with respect to the heat flux sensor (12) to alter the delivery path of the cryogenic substance and the distance (D1) to the at least one organism culture (28).
3. The apparatus according to claim 1 or 2, wherein the cryogen delivery apparatus (16) comprises a spray nozzle, in particular a cone jet.
4. The apparatus according to at least one of claims 1 to 3, wherein the cryogen delivery apparatus (16) emits cryogen spray (18), in particular a cryogen spray cone (19) having a lower most edge at a distance (D2) from the heat flux sensor (12).
5. The apparatus according to at least one of claims 1 to 4, wherein the cryogenic substance is a cryogen selected from the group consisting of liquid nitrogen (LIN), liquid oxygen (LOX), and liquid argon.
6. The apparatus according to at least one of claims 1 to 5, further comprising a source of cryogen in fluid communication with the cryogen delivery apparatus (16).
7. The apparatus according to at least one of claims 1 to 6, wherein the at least one organism culture (28) comprises campylobacter.
8. A method to determine physiological effects of heat flux with a cryogenic substance applied to an organism, comprising:
 - testing at least one organism culture (28) for heat flux with a cryogenic substance; and
 - establishing an amount of heat transfer required at the organism for achieving maximum destruction of said organism.
9. The method according to claim 8, wherein the testing further comprises spraying the cryogenic substance onto the organism for different periods of time.
10. The method according to claim 8 or 9, wherein the cryogenic substance is a cryogen selected from the group consisting of liquid nitrogen (LIN), liquid oxygen (LOX), and liquid argon.
11. The method according to at least one of claims 8 to 10, wherein the testing comprises:
 - contacting the at least one organism culture (28) with the cryogenic substance;
 - observing structural integrity of cells of the at least one organism culture (28);

- adjusting a distance (H) that the cryogenic substance travels for contacting the at least one organism culture (28);
 - adjusting an amount of the cryogenic substance applied to the at least one organism culture (28);
 - adjusting an amount of time the cryogenic substance is applied to the at least one organism culture (28); and
 - 5 - adjusting an amount of heat transfer which occurs from subjecting the at least one organism culture (28) to the cryogenic substance.
12. The method according to claim 11, wherein the observing comprises measuring adenosine triphosphate (ATP) leaking from cell walls of the organism.
- 10
13. The method according to claim 11 or 12, wherein the adjusting the amount of the cryogenic substance comprises emitting the cryogenic substance in a cone shape (19) for covering the at least one organism culture (28).
- 15
14. The method according to at least one of claims 8 to 13, wherein the at least one organism culture (28) comprises campylobacter.
15. The method according to at least one of claims 8 to 14, wherein the testing is with a plurality of organism cultures (28).

FIG. 1

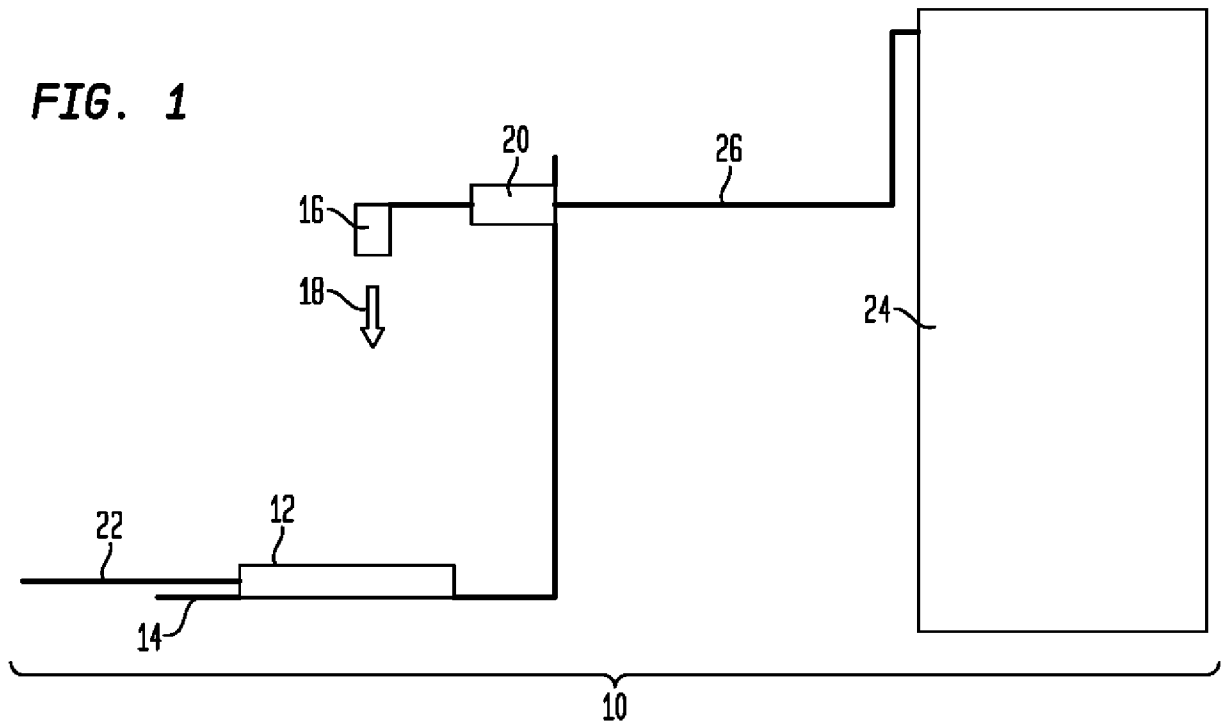


FIG. 2

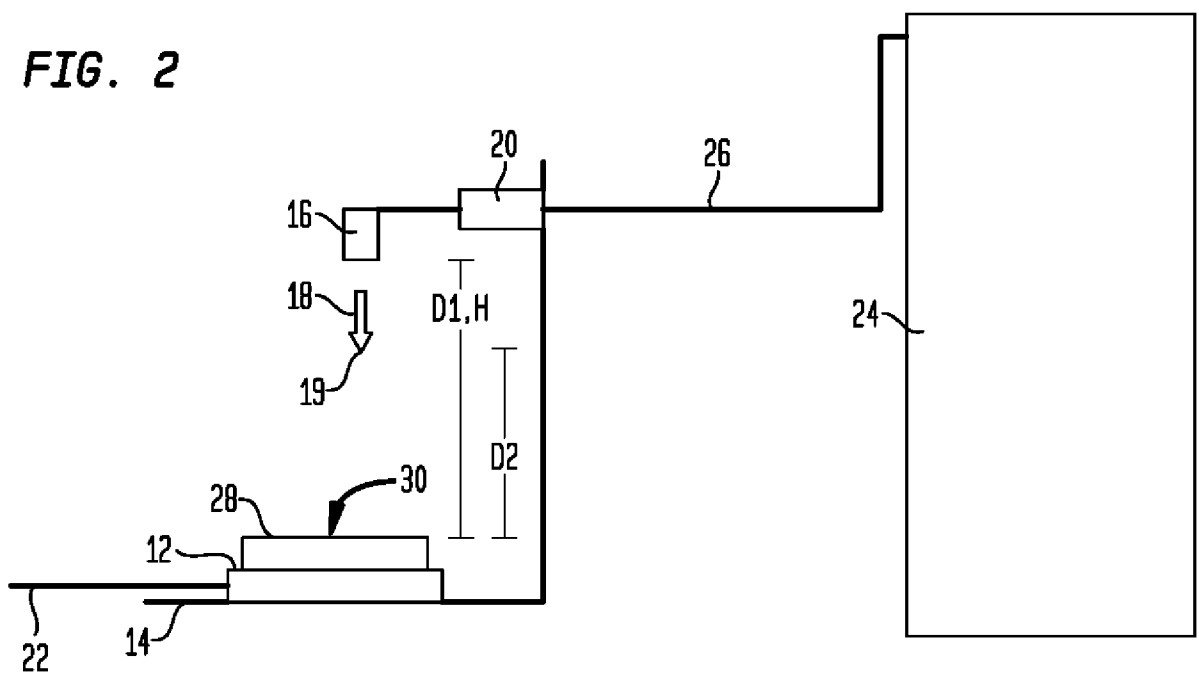
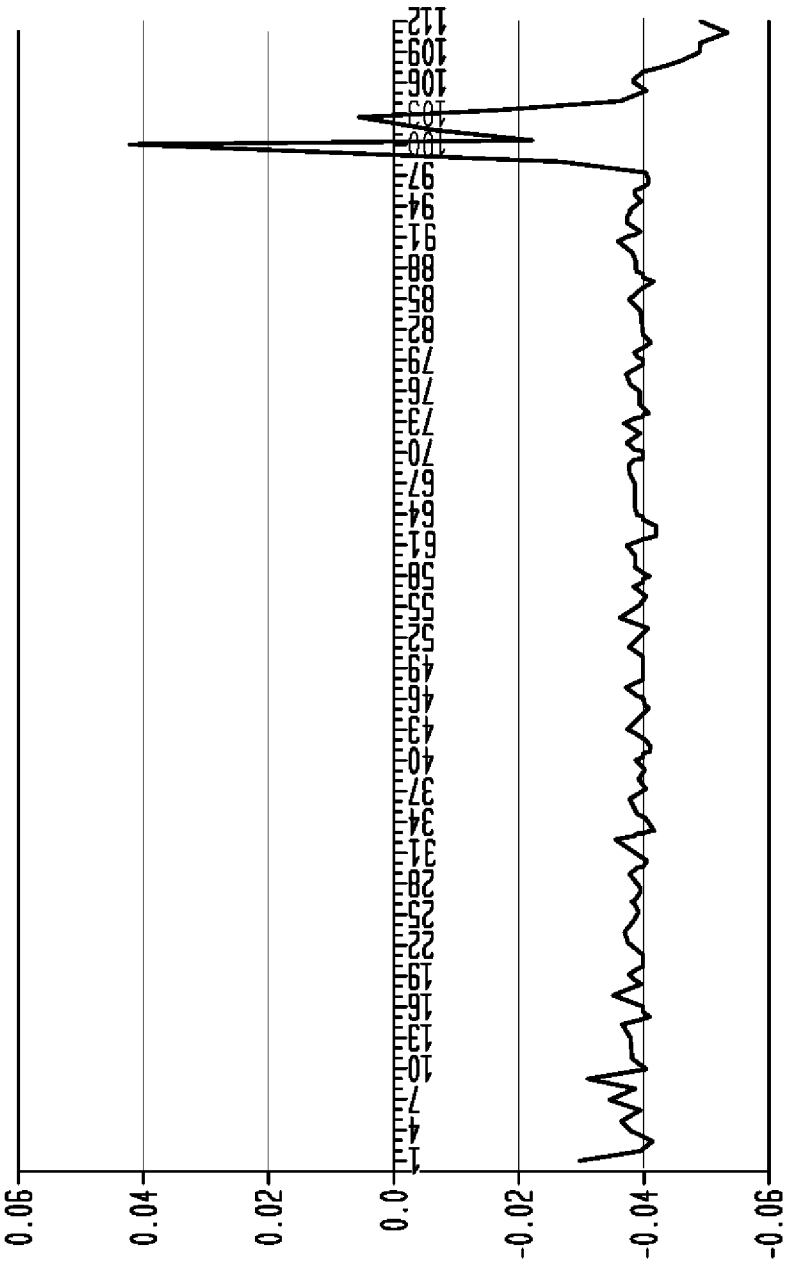


FIG. 3



INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

INV. A23L3/375 A23B4/09 F25D3/11 C12Q1/22 C12M1/34
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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)

A23L F25D C12Q C12M G01N

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, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

☒ See patent family annex.

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Diez Schlereth, D

INTERNATIONAL SEARCH REPORT

International application No
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