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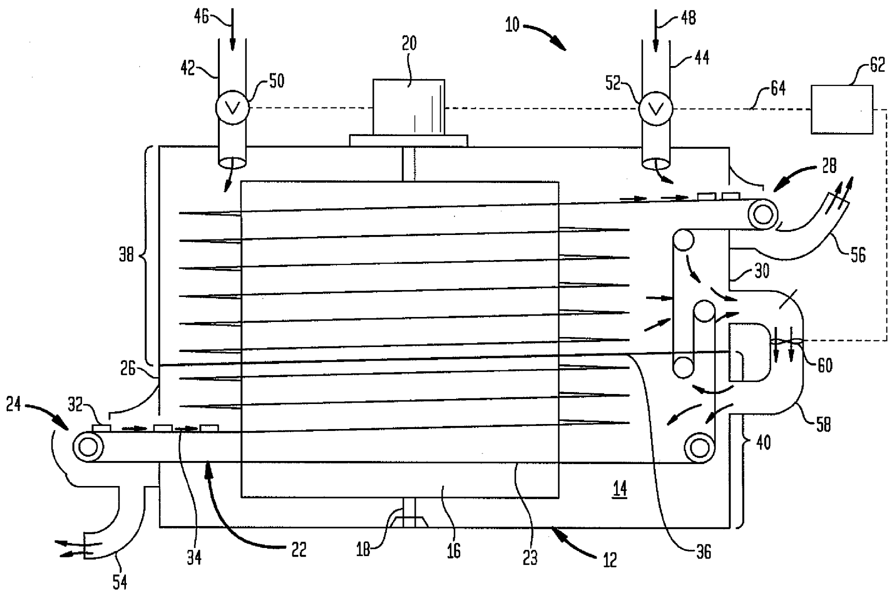
(54) Spiral freezer with precooler

(57) In order to use the exhaust gas of a freezer apparatus (10) to capture gas for additional refrigeration for more efficient use of the freezer apparatus (10), the freezer apparatus (10) comprises
- a housing (12) having a space (14) therein for receiving a cryogen, and an inlet (24) and an outlet (28) in communication with the space (14);
- a conveyor belt (22) having an outer edge (23) and being arranged for movement (34) through the space (14) for transferring a product (32), in particular a food product, from the inlet (24) through to the outlet (28);
- a solid longitudinal member (36), in particular a baffle, disposed in the space (14) adjacent the outer edge (23) of the conveyor belt (22) for segregating the space (14) into an upper chamber (38) and a lower chamber (40); and
- a transfer duct (58) operatively associated with the housing (12) and having a first opening in communication with the upper chamber (38) for receiving the cryogen from the upper chamber (38) and a second opening in communication with the lower chamber (40) for expelling the cryogen into the lower chamber (40).



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Description

Technical field of the present invention

[0001] The present embodiments relate to spiral freezers and related processes wherein a cryogen gas is introduced into the freezer for chilling or freezing of products such as for example food products.

Background of the present invention; prior art

[0002] Exhaust gas from known cryogenic freezing systems is removed as waste and therefore typically hundred percent (100%) of the energy in the exhaust gas is wasted. Spiral freezing systems operate in an isothermal manner (at a constant temperature) and therefore, gas exhausted is usually at the operating temperature of the spiral freezer. This exhaust gas is usually at a temperature of -80°F [= -62.2°C] to -120°F [= -84.4°C].

Disclosure of the present invention: object, solution, advantages

[0003] Starting from the disadvantages and shortcomings as described above and taking the prior art as discussed into account, an object of the present invention is to use the exhaust gas of a spiral freezer or other type of freezer to capture gas for additional refrigeration for more efficient use of the freezer.

[0004] This object is accomplished by an apparatus comprising the features of claim 1. Advantageous embodiments and expedient improvements of the present invention are disclosed in the dependent claims.

[0005] The present invention provides for a precooler apparatus, which may be integrated with a spiral freezer or other type of freezer, to utilize exhaust gas from the freezer to precool a product such as a food product, before entering the main or actual freezing chamber. Such construction and method provides efficiency gains for the freezer, for example less nitrogen (N_2) gas is used in the freezer without diminishing capacity of the freezer.

[0006] More particularly, the freezer apparatus of the present invention comprises

- a housing having a space therein for receiving a cryogen, and an inlet and an outlet in communication with the space;
- a conveyor belt having an outer edge and being arranged for movement through the space for transferring a product, in particular a food product, from the inlet through to the outlet;
- a solid longitudinal member, in particular a baffle, disposed in the space adjacent the outer edge of the conveyor belt for segregating the space into an upper chamber and a lower chamber; and
- a transfer duct operatively associated with the housing and having a first opening in communication with the upper chamber for receiving the cryogen from the upper chamber and a second opening in communication with the lower chamber for expelling the cryogen into the lower chamber.

[0007] The transfer duct may be constructed and arranged with respect to the housing to transfer the cryogen in the upper chamber to the lower chamber by circumventing the solid longitudinal member.

[0008] According to an advantageous embodiment of the present invention, a fan is disposed in the transfer duct for moving the cryogenic gas from the upper chamber through the transfer duct into the lower chamber. More particularly, the fan can be disposed for rotational movement within the transfer duct to draw the cryogenic gas from the upper chamber through the transfer duct into the lower chamber.

[0009] Independently thereof or in connection therewith, the transfer duct

- may be a pipe mounted to a sidewall of the housing, or
- may be integrally formed as part of a sidewall of the housing.

[0010] According to an expedient embodiment of the present invention, the cryogen, such as a cryogenic liquid or a cryogenic gas, for example nitrogen (N_2) or carbon dioxide (CO_2), is provided to the space through at least one passageway, in particular through at least one pipe, being in communication with the upper chamber for introducing the cryogen into the upper chamber.

[0011] According to a favoured embodiment of the present invention, each of the passageways includes a respective valve for controlling the introduction of the cryogen into the space, in particular for regulating the flow of the cryogen to the upper chamber. If a cryogen liquid is used such liquid will usually change phase into a gaseous form upon introduction into the space.

[0012] According to a preferred embodiment of the present invention, a controller communicates with the valve(s) and with the fan, in particular by electronic connection, for generating a signal to control the valve(s) and the fan to regulate an amount of the cryogen introduced into the upper chamber and a flow rate of the cryogen. Such arrangement permits the controller to signal for the necessary flow rate of the cryogen to be introduced into the upper chamber of the space by controlling the openings of the valve(s) and the speed of the fan.

[0013] According to an advantageous embodiment of the present invention, a drum is disposed in the space and has an exterior surface around which the conveyor belt moves. More particularly, the drum may be rotated about an axle to which it is mounted; the axle may be connected to a drive mechanism, in particular to a motor, mounted external to the housing.

[0014] Basically, the conveyor belt is constructed and arranged with respect to the space to introduce products, such as food products, through the inlet into the space where the products are chilled or frozen for being removed from the space through the outlet.

[0015] According to an expedient embodiment of the present invention, the conveyor belt may have an outer edge or periphery arranged for rotational movement in a spiral configuration about the drum.

[0016] Independently thereof or in connection therewith, the conveyor belt may be arranged in a continuous loop.

[0017] Independently thereof or in connection therewith, the conveyor belt may comprise a surface area selected from the group consisting of a solid surface and a mesh surface, and can be formed from plastic, metal or a combination of both.

[0018] According to a favoured embodiment of the present invention, the solid longitudinal member

- is of solid construction, with no cryogen being permitted to pass through the solid longitudinal member, and/or
- is disposed in the space for segregating the space such

  - - that the lower chamber is a precooling zone, and

  - - that the upper chamber is a freezing zone.

[0019] The precooling zone may occupy approximately thirty percent (approximately 30%) of the space, while the freezing zone may occupy approximately seventy percent (approximately 70%) of the space, for example.

[0020] The solid longitudinal member may be arranged in the space so as not to interfere with the rotational movement of the drum and the conveyor belt, and the continuous return arrangement of the conveyor belt between the lower chamber and the upper chamber.

[0021] The solid longitudinal member, in conjunction with the transfer duct, may prevent the gas in the upper chamber from indiscriminately entering the lower chamber, by directing the gas to and through the transfer duct in a controlled flow depending upon the temperature to be used in the lower chamber.

[0022] Independently thereof or in connection therewith, a pressure of an upper atmosphere in the upper chamber and another pressure of a lower atmosphere in the lower chamber are greater than an ambient pressure external to the housing.

[0023] According to a preferred embodiment of the present invention, the housing may be provided

- with a first exhaust, in particular with a precooling zone exhaust duct, arranged in communication with the lower chamber and constructed for example at the first sidewall proximate the inlet, and
- with a second exhaust, in particular with a freezing zone exhaust duct, arranged in communication with the upper chamber and constructed for example at the other sidewall proximate the outlet.

[0024] The inlet and the outlet may optionally be disposed at opposed sides of the housing.

[0025] The present embodiments can be used with a cryogen such as for example liquid or gaseous carbon dioxide (CO_2) or nitrogen (N_2).

Brief description of the drawings

[0026] 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; further improvements, features and advantages of the present invention are explained below in more detail with reference to preferred embodiments by way of non-limiting example and to the appended drawing figure taken in conjunction with the description of the embodiments, of which the Figure is a partial cross-sectional view of a spiral freezer according to the present invention having a precooler for the freezer.

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

[0027] Referring to the Figure, a spiral freezer with precooler apparatus is shown generally at 10. The freezer 10 includes a housing 12 with a chamber 14 arranged therein for receiving a drum 16 for rotational movement within the chamber 14. The drum 16 is rotated about an axle 18 to which it is mounted; the axle 18 is connected to a drive mechanism 20 (such as a motor) mounted external to the housing 12.

[0028] A conveyor belt 22 having an outer edge 23 or periphery is arranged for rotational movement in a spiral configuration about the drum 16. The conveyor belt 22 may be of the continuous type as shown in the Figure. The housing 12 includes an inlet 24 at a side 26 of the housing 12, and an outlet 28 at another side 30 of the housing 12. The inlet 24 and the outlet 28 may optionally be disposed at opposed sides of the housing 12.

[0029] The conveyor belt 22 is constructed and arranged with respect to the chamber 14 to introduce products 32, such as food products, through the inlet 24 in the direction of the arrows 34 into the chamber 14 where the products 32 are chilled or frozen for being removed from the chamber through the outlet 28.

[0030] A baffle 36 is disposed in the chamber 14 for segregating the chamber 14 into an upper freezing zone 38 above the baffle 36, while the area below the baffle 36 is a lower precooling zone 40. The freezing zone 38 occupies approximately seventy percent (approximately 70%) of the chamber 14, while the precooling zone 40 occupies approximately thirty percent (approximately 30%) of the chamber 14, for example.

[0031] A cryogen, such as a cryogenic liquid or gas, for example nitrogen (N_2) or carbon dioxide (CO_2), is provided to the chamber 14 through the pipes 42, 44 as indicated by the arrows 46, 48, respectively. Each of the pipes 42, 44 includes a respective valve 50, 52 for controlling introduction of the cryogen into the chamber 14. If a cryogen liquid 46, 48 is used such liquid will usually change phase into a gaseous form upon introduction into the chamber 14. By way of example only reference herein may be to a cryogenic gas, due to the phase change.

[0032] The conveyor belt 22 can be a mesh or solid construction, and can be formed from plastic, metal or a combination of both.

[0033] The housing 12 is provided with a precooling zone exhaust duct 54 constructed and arranged for example at the first side 26 proximate the inlet 24, and a freezing zone exhaust duct 56 constructed and arranged for example at the other side 30 proximate the outlet 28.

[0034] A transfer duct 58 is constructed and arranged with respect to the housing 12 to transfer the cryogenic gas 46, 48 in the freezing zone 38 to the precooling zone 40 by circumventing the baffle 36. The baffle 36 is of solid construction, i.e. no cryogen gas is permitted to pass through the baffle.

[0035] A fan 60 is disposed for rotational movement within the transfer duct 58 to draw the cryogenic gas 46, 48 from the freezing zone 38 through the transfer duct 58 into the precooling zone 40. The transfer duct 58 may be a pipe mounted to the sidewall 30, or may be integrally formed as part of the sidewall 30.

[0036] The baffle 36 is arranged in the chamber 14 so as not to interfere with the rotational movement of the drum 16 and the conveyor belt 22, and the continuous return arrangement of the belt 22 between the zones 38, 40.

[0037] A controller 62 is electronically connected as shown by the broken line 64 to the valves 50, 52 and the fan 60. This arrangement permits the controller 62 to signal for the necessary flow rate of the cryogenic gas 46, 48 to be introduced into the freezing zone 38 of the chamber 14 by controlling the openings of the valves 50, 52 and the speed of the fan 60.

[0038] The apparatus 10 prevents air or atmosphere external to the housing 12 from entering the inlet 24 and the outlet 28 by injecting hundred percent (100%) of the total mass flow into the freezing zone 38 and then allowing only ninety percent (90%) of the total mass flow to enter the precooling zone 40. There can always be a given flow rate of cryogen into the chamber 14. The flow rate can be designated as "X" (not shown in the Figure).

[0039] The controller 62 opens or closes valves 50, 52 to a specific orifice diameter so that the flow rate of cryogen into the apparatus 10 maintains a setpoint temperature in the upper freezing zone 38. Because the actual position of the control valves 50, 52 is known, and the pressure and temperature of the cryogen 46, 48 entering through the valves are known, the actually mass flow rate of the cryogen into the apparatus is also known.

[0040] The controller 62 operates the fan 60 to draw a mass flow rate of 0.9X (ninety percent of X). The fan 60 is operated by a variable speed motor (not shown), so varying the motor speed is directly proportional to the mass flow rate of gas drawn through the transfer duct 58 by the fan. Only ninety percent (90%) of the mass flow is drawn from the upper freezing zone 38 into the lower precooling zone 40, because ten percent (10%) of the gas must be allowed to exit the system under pressure at the outlet 28 of the apparatus 10. This is to prevent external warm air from entering the freezer apparatus.

[0041] The remaining ninety percent (90%) of the mass flow, now in the lower precooling zone 40 below the baffle 36 is exhausted from the precooling zone exhaust duct 54 and/or a central exhaust port (not shown). A signal from the controller 62 which controls the variable speed fan 60 in conjunction with the valve 50, 52 openings permits the apparatus 10 to maintain the necessary mass volume in the chamber 14. A remaining ten percent (10%) of the cryogenic gas introduced into the chamber 14 at the freezing zone 38 can be exhausted through the outlet 28.

[0042] As the fan 60 draws the cryogenic gas 46, 48 from the freezing zone 38 through the transfer duct 58 into the precooling zone 40, the gas comes in contact with the warmer product 32, which has entered the precooling zone 40 from the inlet 24, to remove energy from the food product 32 prior to it entering the freezing zone 38.

[0043] The cryogenic gas provided from the transfer duct 58 into the precooling zone 40 can now be exhausted at the precooling zone duct 54 at a significantly warmer temperature (approximately- 20°F [=- 28.8°C]), thereby increasing the overall efficiency of the apparatus 10. This is because the food product 32 has been precooled in the precooling zone 40 such that a lesser amount of the cryogen gas 46, 48 is necessary in the freezing zone 38 in order to reduce the temperature of the food product 32 to that which is needed.

[0044] In the Example where the cryogenic gas 46, 48 is introduced into the chamber 14 through the pipes 42, 44, the gas is at -80°F [= -62.2°C]. There would therefore be a nine percent (9%) to eleven percent (11%) overall cryogen efficiency gained. If the upper freezing zone 38 was operated at -80°F and the lower precooling zone 40 at -20°F, the following calculation is an Example comparing a conventional isothermal spiral freezer with the present embodiment, as an isothermal spiral freezer would operate and exhaust the gas at -80°F (-80°F minus -20°F is -60°F).

See the following Example:

[0045] Conventional Isothermal Spiral Freezer Exhaust = -80°F [= -62.2°C]

[0046] Dual Zone Precooler Spiral Freezer 10 Exhaust 54 = -20°F [= -28.8°C]

[0047] Liquid Nitrogen (= LN_2) Efficiency of Conventional Isothermal Spiral Freezer:

- Assume LN_2 at 30 psig [= thirty pounds per square inch gauge = 3.08 bar = 308167.7 Pa(scal)] and at a saturated state entering the freezer.
- LN_2 heat of vaporization = 78.8 Btu/Ib [= 183288.8 m^2/s^2 = 183.2 J/g = 183.2 kG (ra) y], therefore total potential refrigeration = 78.8 Btu/Ib + 0.24 Btu/ (Ib*°F) x ABS [- 300°F- (- 80°F)] .
- (the delta T or ΔT = ABS [- 320°F- (- 80°F)]
 - 0.24 Btu/ (Ib*°F) (specific heat of nitrogen gas) .
 ~Δ T = ABS [- 300°F- (- 80°F)], where
 - 300°F = temperature of LN_2 entering freezer, and
 - 80°F = exhaust temperature of gas exiting freezer.
 78.8 Btu/Ib + 0.24 Btu/ (Ib*°F) x 220°F = 131.6 Btu/Ib [= 306101.6 m^2/s^2 = 306.1 J/g = 306.1 kG (ra) y]

[0048] Liquid Nitrogen (= LN_2) Efficiency of Dual Zone Precooler Spiral Freezer 10:

- Assume LN_2 at 30 psig [= thirty pounds per square inch gauge = 3.08 bar = 308167.7 Pa(scal)] and at a saturated state entering the freezer.
- Ninety percent (= 90%) of exhaust gas leaves freezer through exhaust duct 54 of precooler zone 40 at a temperature of -20°F [= -28.8°C].
- Ten percent (= 10%) of exhaust gas leaves freezer through exhaust duct 56 of freezing zone 38 at a temperature of -80°F [= -62.2°C].

[0049] Therefore, total potential refrigeration is
78.8 Btu/Ib + 0.9 x 0.24 Btu/ (Ib*°F) x ABS [- 300°F- (- 20°F)] + 0.1 x 0.24 Btu/ (Ib*°F) x ABS [- 300°F- (- 80°F)] = 78.8 Btu/Ib + 0.9 x 0.24 Btu/ (Ib*°F) x 280°F + 0.1 x 0.24 Btu/ (Ib*°F) x 220
= 78.8 Btu/Ib + 60.5 Btu/Ib + 5.3 Btu/Ib
= 144.6 Btu/Ib [= 336339.6 m^2/s^2 = 336.3 J/g = 336.3 kG (ra) y]

[0050] LN_2 Efficiency Ratio of Dual Zone Precooler Spiral Freezer 10 versus Conventional Isothermal Spiral Freezer: 144.6 Btu/Ib / 131.6 Btu/Ib = 1.098 or 9.8% Cryogen Efficiency Gain

[0051] The 9.8 percent represents the overall increase in the capacity of the cryogen used in the apparatus 10 to absorb heat. This is referred to as the cryogen efficiency. Therefore, for the same mass flow rate of cryogen used in a conventional isothermal spiral freezer and in the dual zone freezer apparatus 10, the present apparatus 10 provides for the cryogenic gas 46, 48 to remove 9.8 percent more heat from the apparatus.

[0052] As more cryogen gas 46, 48 is introduced into the upper freezing zone 38, the controller 62 will increase the speed of the fan 60 which will increase the mass flow of cryogen into the lower precooling zone 40. The fan 60 is controlled by the controller 62 to pull or draw the cryogenic gas at a higher volumetric flow rate.

[0053] The baffle 36, in conjunction with the transfer duct 58, prevents the gas 46, 48 in the freezing zone 38 from indiscriminately entering the precooling zone 40, by directing the gas to and through the duct 58 in a controlled flow depending upon the temperature to be used in the precooling zone.

[0054] 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

[0055]

10	freezer apparatus, in particular spiral freezer with precooler apparatus
12	housing
14	chamber or space
16	drum
18	axle
20	drive mechanism, in particular motor
22	conveyor belt
23	outer edge or periphery of conveyor belt 22
24	inlet
26	one side or first side or first sidewall of housing 12
28	outlet
30	other side or second side or second sidewall of housing 12
32	product, in particular food product
34	(direction of) movement of conveyor belt 22
36	solid longitudinal member, in particular baffle
38	upper chamber or freezing zone, in particular upper freezing zone
40	lower chamber or precooling zone, in particular lower precooling zone
42	passageway, in particular pipe
44	passageway, in particular pipe
46	cryogen, in particular cryogenic liquid or cryogenic gas, for example nitrogen (N_2) or carbon dioxide (CO_2), in passageway 42
48	cryogen, in particular cryogenic liquid or cryogenic gas, for example nitrogen (N_2) or carbon dioxide (CO_2), in passageway 44
50	valve in passageway 42
52	valve in passageway 42
54	first exhaust, in particular precooling zone exhaust duct
56	second exhaust, in particular freezing zone exhaust duct
58	transfer duct
60	fan, in particular variable speed fan
62	controller
64	communication, in particular electronic connection

Claims

1. A freezer apparatus (10), comprising:

- a housing (12) having a space (14) therein for receiving a cryogen, and an inlet (24) and an outlet (28) in communication with the space (14);
- a conveyor belt (22) having an outer edge (23) and being arranged for movement (34) through the space (14) for transferring a product (32), in particular a food product, from the inlet (24) through to the outlet (28);
- a solid longitudinal member (36), in particular a baffle, disposed in the space (14) adjacent the outer edge (23) of the conveyor belt (22) for segregating the space (14) into an upper chamber (38) and a lower chamber (40); and
- a transfer duct (58) operatively associated with the housing (12) and having a first opening in communication with the upper chamber (38) for receiving the cryogen from the upper chamber (38) and a second opening in communication with the lower chamber (40) for expelling the cryogen into the lower chamber (40).

2. The freezer apparatus according to claim 1, further comprising at least one passageway (42, 44), in particular at least one pipe, in communication with the upper chamber (38) for introducing the cryogen (46, 48) into the upper chamber (38).

3. The freezer apparatus according to claim 2, further comprising a valve (50, 52) interposed in the at least one passageway (42, 44) for regulating flow of the cryogen (46, 48) to the upper chamber (38).

4. The freezer apparatus according to at least one of claims 1 to 3, further comprising a fan (60) disposed in the transfer duct (58) for moving the cryogen from the upper chamber (38) through the transfer duct (58) into the lower chamber (40).

5. The freezer apparatus according to claim 3 and 4, further comprising a controller (62) in communication (64), in particular in particular electronic connection, with the valve (50, 52) and the fan (60) for generating a signal to control the valve (50, 52) and the fan (60) to regulate an amount of the cryogen (46, 48) introduced into the upper chamber (38) and a flow rate of the cryogen (46, 48).

6. The freezer apparatus according to at least one of claims 1 to 5, further comprising a drum (16) disposed in the space (14) and having an exterior surface around which the conveyor belt (22) moves (34).

7. The freezer apparatus according to at least one of claims 1 to 6, wherein the conveyor belt (22) is arranged in a continuous loop.

8. The freezer apparatus according to at least one of claims 1 to 7, wherein the conveyor belt (22) comprises a surface area selected from the group consisting of a solid surface and a mesh surface.

9. The freezer apparatus according to at least one of claims 1 to 8, wherein

- the lower chamber (40) is a precooling zone, and
- the upper chamber (38) is a freezing zone.

10. The freezer apparatus according to at least one of claims 1 to 9, further comprising

- a first exhaust (54) in communication with the lower chamber (40), and
- a second exhaust (56) in communication with the upper chamber (38).

11. The freezer apparatus according to claim 9 and 10, wherein

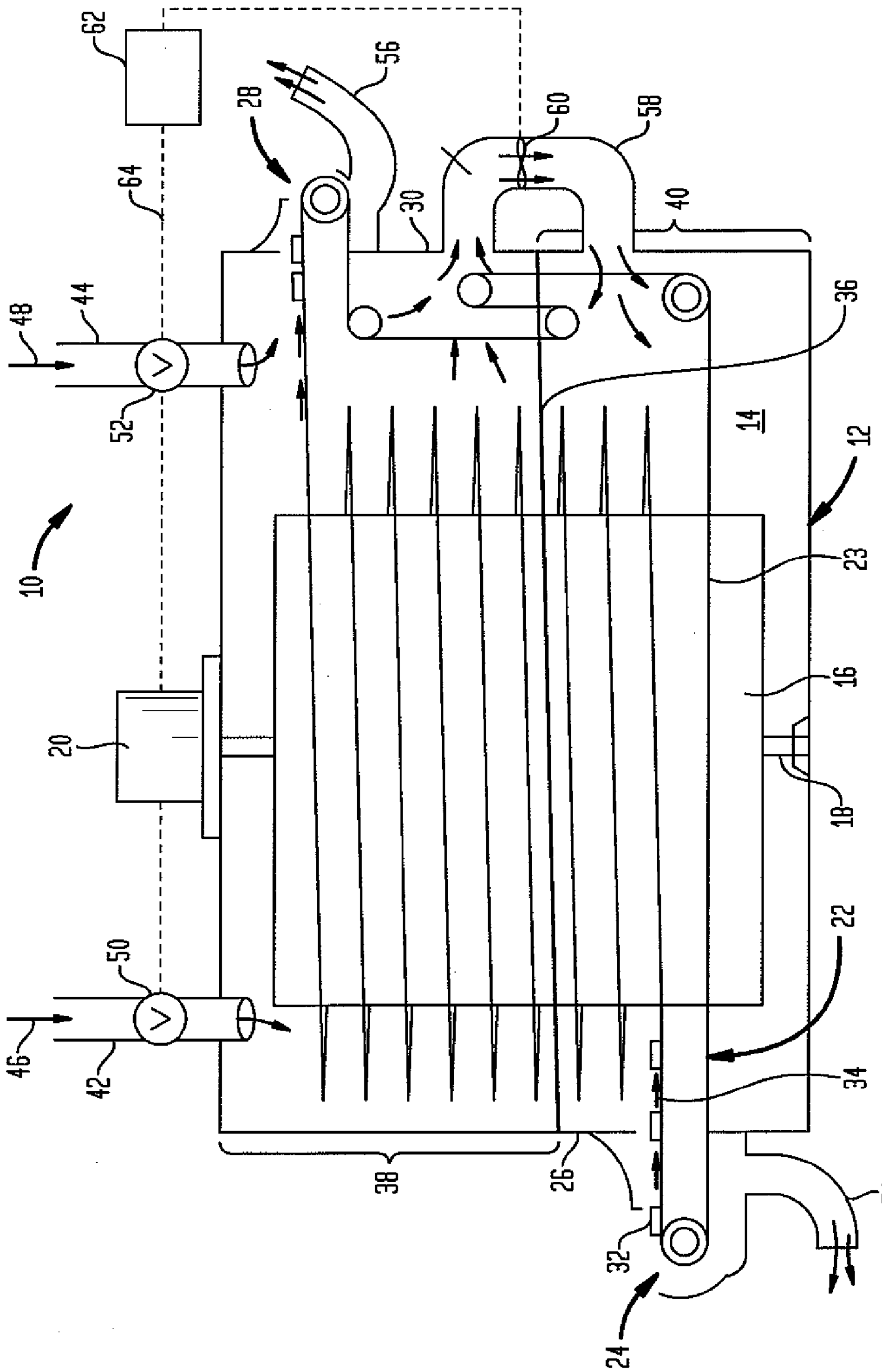
- the first exhaust (54) is a precooling zone exhaust duct, and
- the second exhaust (56) is a freezing zone exhaust duct.

12. The freezer apparatus according to at least one of claims 1 to 11, wherein the transfer duct (58) comprises a pipe mounted to a sidewall (30) of the housing (12).

13. The freezer apparatus according to at least one of claims 1 to 12, wherein the transfer duct (58) is formed integral with a sidewall (30) of the housing (12).

14. The freezer apparatus according to at least one of claims 1 to 13, wherein a pressure of an upper atmosphere in the upper chamber (38) and another pressure of a lower atmosphere in the lower chamber (40) are greater than an ambient pressure external to the housing (12).

15. The freezer apparatus according to at least one of claims 1 to 14, wherein the cryogen is a cryogenic gas, in particular comprising at least one of nitrogen (N_2) or carbon dioxide (CO_2).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EUROPEAN SEARCH REPORT

Application Number
EP 12 19 2149

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	9 January 2013	de Graaf, Jan Douwe

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 19 2149

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82