

EUROPEAN PATENT APPLICATION

Application number: **86201039.4**

Int. Cl.4: **F25B 1/00 , F25D 31/00**

Date of filing: **13.06.86**

Priority: **10.07.85 NL 8501978**

Date of publication of application:
21.01.87 Bulletin 87/04

Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

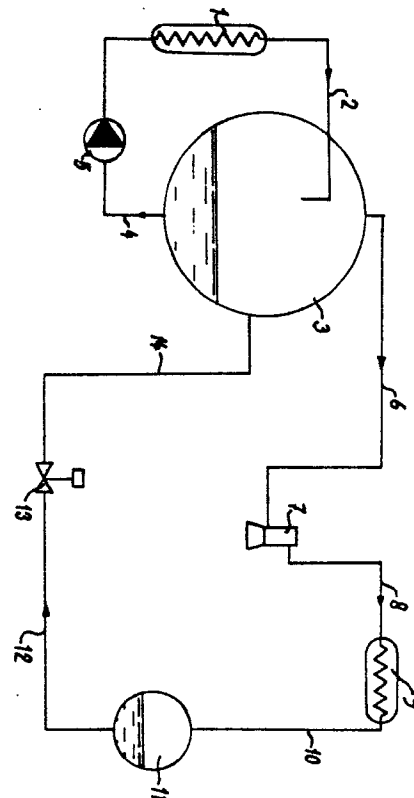
Applicant: **GRASSO'S KONINKLIJKE
MACHINEFABRIEKEN N.V.**
P.O. Box 275
NL-5201 AG 's-Hertogenbosch(NL)

Inventor: **Verhoef, Hermanus Johan Nicolaas**
Coba Pulsenstraat 9
NL-5224 JD s'-Hertogenbosch(NL)

Representative: **van der Beek, George Frans**
et al
Nederlandsch Octrooibureau Johan de
Wittlaan 15 P.O. Box 29720
NL-2502 LS 's-Gravenhage(NL)

Method of operating an installation for refrigerating products under vacuum.

Method of operating an installation for refrigerating products under vacuum, such as lettuce, which installation comprises a closable vessel for the products, one or more vacuum pumps adapted to produce a vacuum in the interior of the vessel, a water vapour condenser (1) disposed in the vessel through which a refrigerant can be passed, and a refrigerating unit comprising a compressor (7), a condenser (9) and a throttle valve (13), disposed outside the vessel and an evaporator being formed by said water vapour condenser (1) disposed in the vessel, whereby a low-pressure separator (3) is provided for liquid and vaporous refrigerant, the suction pipe (6) of the compressor (7) and the outlet pipe (14) of the throttle valve (13), as well as the two pipes (2 and 4) of the water vapour condenser (1), being connected to said separator, while a high-pressure vessel (11) for liquid refrigerant is disposed between the refrigerant condenser (9) and the throttle valve (13), whereby the compressor (7) is brought into action, with the throttle valve (13) open, approximately simultaneously with the vacuum pump or pumps and the throttle valve (13) is closed at reaching the evaporation temperature of the water in the product.



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Method of operating an installation for refrigerating products under vacuum.

The invention relates to a method of operating an installation for refrigerating products under vacuum, particularly products consisting mainly of water, such as lettuce, which installation comprises a closable vessel for the products, one or more vacuum pumps adapted to produce a vacuum in the interior of the vessel, a water vapour condenser disposed in the vessel and through which a refrigerant can be passed, and a refrigerating unit comprising a compressor, a condenser and a throttle valve, disposed outside the vessel and an evaporator being formed by said water vapour condenser disposed in the vessel, whereby a low-pressure separator is provided for liquid and vaporous refrigerant, the suction pipe of the compressor and the outlet pipe of the throttle valve as well as the two pipes of the water vapour condensor, being connected to said separator, while a high-pressure vessel for liquid refrigerant is disposed between the refrigerant condensor and the throttle valve.

Such a method is described in US Patent 2,748,576.

The desired boiling temperature (flash point) of the water is obtained by lowering the pressure in the installation with the aid of the vacuum pump or pumps. Heat is required to evaporate water, and this will be taken from the product.

A method of this kind is not carried out continuously but by the batch method, that is to say load by load.

After the installation has been loaded up, the vessel is closed. The vacuum pump is operated until the water in the product is evaporated (flash point). The water vapour formed is condensed on the water vapour condenser, while the vacuum pump draws off the non-condensable gases, such as air.

When the desired final temperature of the product is reached, the vacuum is released and the installation opened.

The refrigerated load can then be replaced by a new load for refrigeration.

The vacuum pump remains in operation even when the flash point has been reached. From that moment on the compressor is also normally brought into action in order to pass refrigerant through the condenser and to condense the water vapour.

As an example a cycle of 20 minutes may be mentioned, comprising 8 minutes for producing the vacuum, 8 minutes for the refrigeration, and 4 minutes for loading and unloading. During this cycle time the vacuum pump then operates for 16 minutes and the refrigerating unit for 8 minutes.

This means that the refrigerating unit must remove all the heat from the product in 8 minutes.

There is little sense in keeping the water vapour condenser at a very low temperature through operation of the refrigerating unit before the flash point is reached.

The invention seeks to modify the known method in such a manner that a much smaller and therefore less expensive refrigerating unit can be used, and the compressor and the refrigerant condenser may have the half size and the efficiency of the vacuum pump(s) during vacuumation can be highly improved.

According to the invention this can be achieved in that the compressor is brought into action, with the throttle valve open, approximately simultaneously with the vacuum pump or pumps and that the throttle valve is closed at reaching of the evaporation temperature of the water in the product.

In this way it is possible to create a "stock" of cold even before the flash point is reached. This "stock" is used after the flash point has been reached.

The invention will be explained more fully with the aid of an operating diagram.

The water vapour condenser disposed in the vacuum tank is designated 1; it is generally divided into a plurality of condenser sections. From this condenser 1 a pipe 2 extends to the top gas part of a liquid-gas separator 3 for a refrigerant, for example R 22.

From the bottom liquid part of the separator 3 a pipe 4 extends back to the water vapour condenser 1.

A pump 5 is provided in this pipe 4. This pump 5 circulates refrigerant through 1, 2, 3, 4 and 5.

This forms one branch of the refrigerant circuit. The other branch is formed by a suction pipe 6 connected to the end of the separator 3, a compressor 7, a pressure pipe 8, a refrigerant condenser 9, a pipe 10, a reservoir 11 for liquid refrigerant, a pipe 12, a throttle valve 13 for liquid refrigerant, and a pipe 14 returning to the gas part of the separator 3.

As soon as the installation is filled with a load for refrigeration and the formation of the vacuum starts, the compressor 7 is also put into action.

This compressor 7 ensures that liquid refrigerant contained in the high-pressure vessel 11, and having for example a temperature of + 35° C, is conducted to the low-pressure vessel 3. The temperature of the refrigerant is thus lowered to, for example, -5° C or even lower, for example -20°.

A large amount of refrigerant is thus put into stock before the product gives up its heat. This thus takes place during the first 8 minutes of the cycle time of 20 minutes taken as an example and including aeration, loading and unloading.

During this so-called prerefrigeration period the pipes of the water vapour condenser 1 are thereby brought for example to a temperature of -5° or even lower. The vapour pressure of the water vapour in the installation thus falls to below 4 millibars. This means that with a pressure of about 46 millibars in the vessel the vacuum pump must draw in a gas mixture consisting of about 10% water vapour and 90% air. The rate at which the vacuum is produced is thereby approximately doubled, in the ratio of 50 : 90.

When the pipes of the water vapour condenser 1 are not precooled, they have a temperature of, for example, $+20^{\circ}$, corresponding to a pressure of the water vapour in the gas mixture of 23 millibars. This means that when the totale pressure has been reduced to 46 millibars by the vacuum pump the mixture flowing over the pipes of the water vapour condenser 1 then consists of 50 parts by volume of air.

In the case of precooling the mixture consists of 10% water vapour and 90% air.

Because of the precooling, moreover, the water vapour is deposited on the pipes of the condenser in the form of ice. A coating of ice is thus formed. The adhering water drops also freeze, assisted by the low temperature of the material of the pipes.

When the flash point is reached, the throttle valve 13 is closed and the compressor 7 continues to operate. No further warm liquid refrigerant is thus conducted from the high-pressure vessel 11 to the separator 3, and consequently no more expansion vapour is produced in the low-pressure separator 3.

The vaporous refrigerant extracted from the separator 3 by the compressor 7 via the pipe 6 consists solely of vapour generated by heat from the product.

This heat is removed from the product via the water vapour condenser 1.

The ballast of the flash vapour and the warm refrigerant liquid has thus been eliminated.

The vapour compressed by the compressor 7 is condensed in the condenser 9 and then deposited as a liquid in the high-pressure vessel 11, where it is kept for the next cycle.

A conventional refrigeration circuit is in fact divided into two incomplete circuits.

In the circuit 7, 8, 9, 10, 11, 12, 13, 14, 3, 6 warm liquid refrigerant is converted into cold liquid and flash vapour, and in the circuit 1, 2, 3, 4, 5 cold liquid refrigerant is converted back into vapour by the supply of heat from the product.

The effect is thereby achieved that the compressor 7 and the condenser 9 can be about half the size in comparison with a conventional vacuum refrigeration installation, as calculated in the following example.

Assuming that during the cooling of the product 200 kg of R22 refrigerant are evaporated, then

$$200 \times 209 = 41,800 \text{ kJ of heat}$$

are extracted from the product.

If the liquid in the high-pressure vessel 11 is at $+35^{\circ}$, the enthalpy of the liquid R22 is equal to 243 kJ/kg.

When this liquid flows through the throttle valve 13 about 27% of gas is formed downstream of the throttle valve 13 with a mean evaporation temperature of -5°C in the low-pressure vessel 3. In order to obtain 200 kg nett of R22 in the low-pressure vessel 3, $200/73 \times 27 = 73$ kg more must be added.

The enthalpy of R22 gas at -5°C is 403 kJ/kg. For the cooling of the warm R22 liquid the compressor takes off $73(403-243) = 11,680$ kJ in the vacuum production period.

In the low-pressure vessel 3 there are for example still 800 kg of R22 from the previous refrigeration cycle, with a temperature of -5°C . After the low-pressure vessel 3 has been filled with the required 200 kg of R22, R22 can be further cooled to, for example, -15°C , for which purpose the compressor must take off $1000 \cdot 11.5 = 11,500$ kJ.

All in all, the compressor can already produce in the first 8 minutes of the process (the product not yet giving up heat) $11,680 + 11,500 + 23,180$ kJ, which is more than half the total amount of "heat" required, so that the refrigeration installation is about half the size.

The consumption of energy remains approximately the same, but the installation becomes much smaller.

Claims

Method of operating an installation for refrigerating products under vacuum, particularly products consisting mainly of water, such as lettuce, which installation comprises a closable vessel for the products, one or more vacuum pumps adapted to produce a vacuum in the interior of the vessel, a water vapour condenser (1) disposed in the vessel through which a refrigerant can be passed, and a refrigerating unit comprising a compressor (7), a condenser (9) and a throttle valve (13), disposed outside the vessel and an evaporator being formed by said water vapour condenser (1) disposed in the vessel, whereby a low-pressure separator (3) is

provided for liquid and vaporous refrigerant, the suction pipe (6) of the compressor (7) and the outlet pipe (14) of the throttle valve (13), as well as the two pipes (2 and 4) of the water vapour condenser (1), being connected to said separator, while a high-pressure vessel (11) for liquid refrigerant is disposed between the refrigerant condenser -

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(9) and the throttle valve (13), **characterized** in that the compressor (7) is brought into action, with the throttle valve (13) open, approximately simultaneously with the vacuum pump or pumps and that the throttle valve (13) is closed at reaching of the evaporation temperature of the water in the product.

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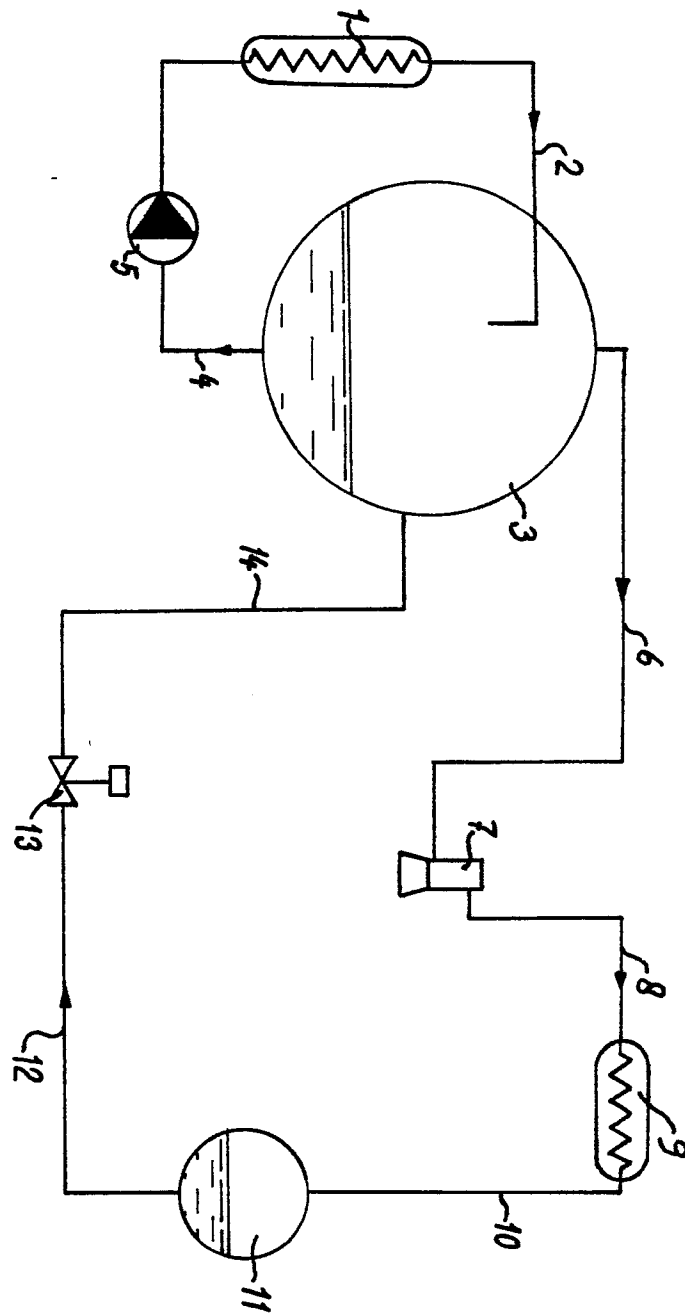
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D,A	US-A-2 748 576 (PEUKERT Sr. et al.) * Whole document *	1	F 25 B 1/00 F 25 D 31/00
A	--- KOELTECHNIEK, vol. 74, no. 5, May 1981, pages 106-110; H.J.N. VERHOEF: "Aspecten bij het ontwerpen van vacuumkoelinstallaties" * Pages 109,110 *	1	
A	--- US-A-3 319 434 (MATESANZ) * Whole document *	1	

			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			F 25 B F 25 D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14-10-1986	Examiner SILVIS H.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	