United States Patent

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[54] COLD TRAP ICE-REMOVAL MEANS FOR VACUUM DRYING SYSTEMS

9 Claims, 4 Drawing Figs.

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[51] Int. Cl. B01d 5/00
[50] Field of Search 62/55.5; 34/5; 34/92

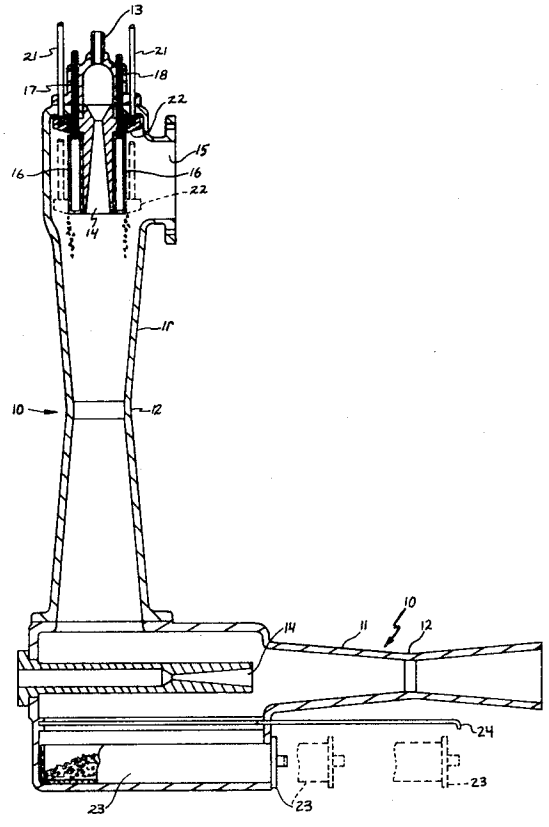
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ABSTRACT: In abstract, a preferred embodiment of this invention is a deicing device for cold traps used to remove condensable vapors from vacuum chambers. The invention is particularly beneficial in maintaining constant maximum system efficiency during commercial type vacuum vapor removal or vapor reclamation associated with chemical processes or food processing.



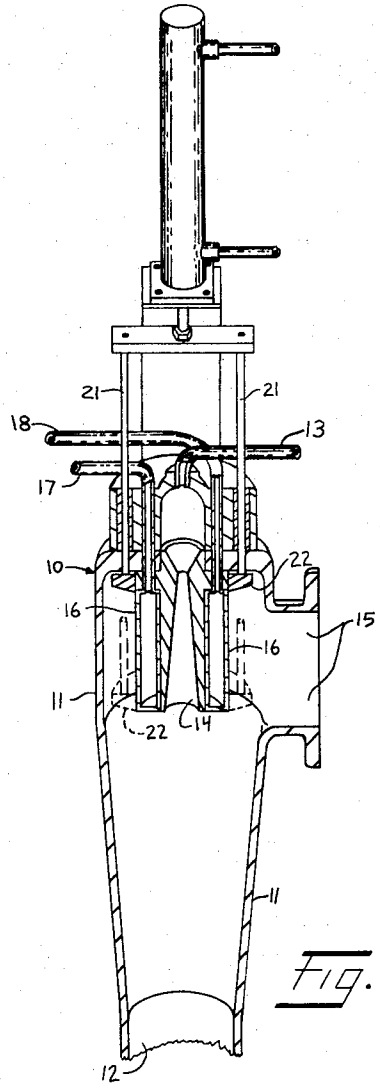


Fig. 1

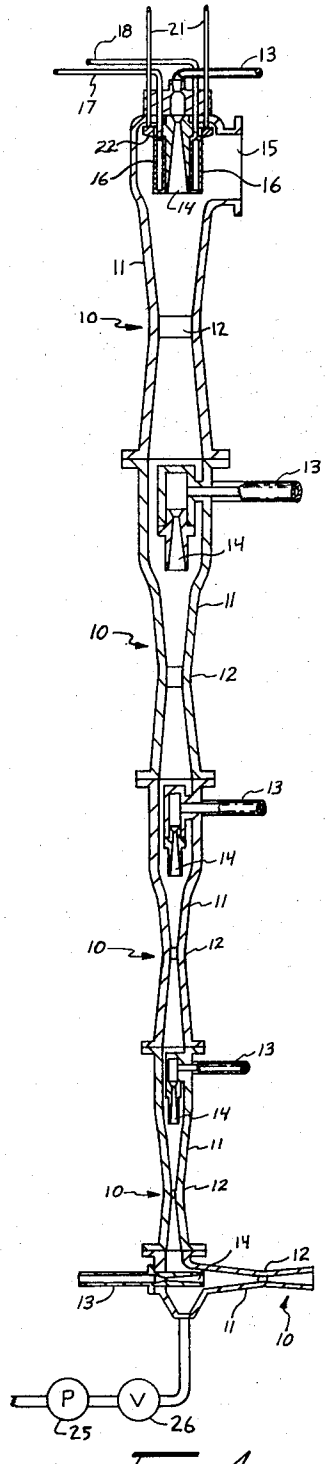


Fig. 4

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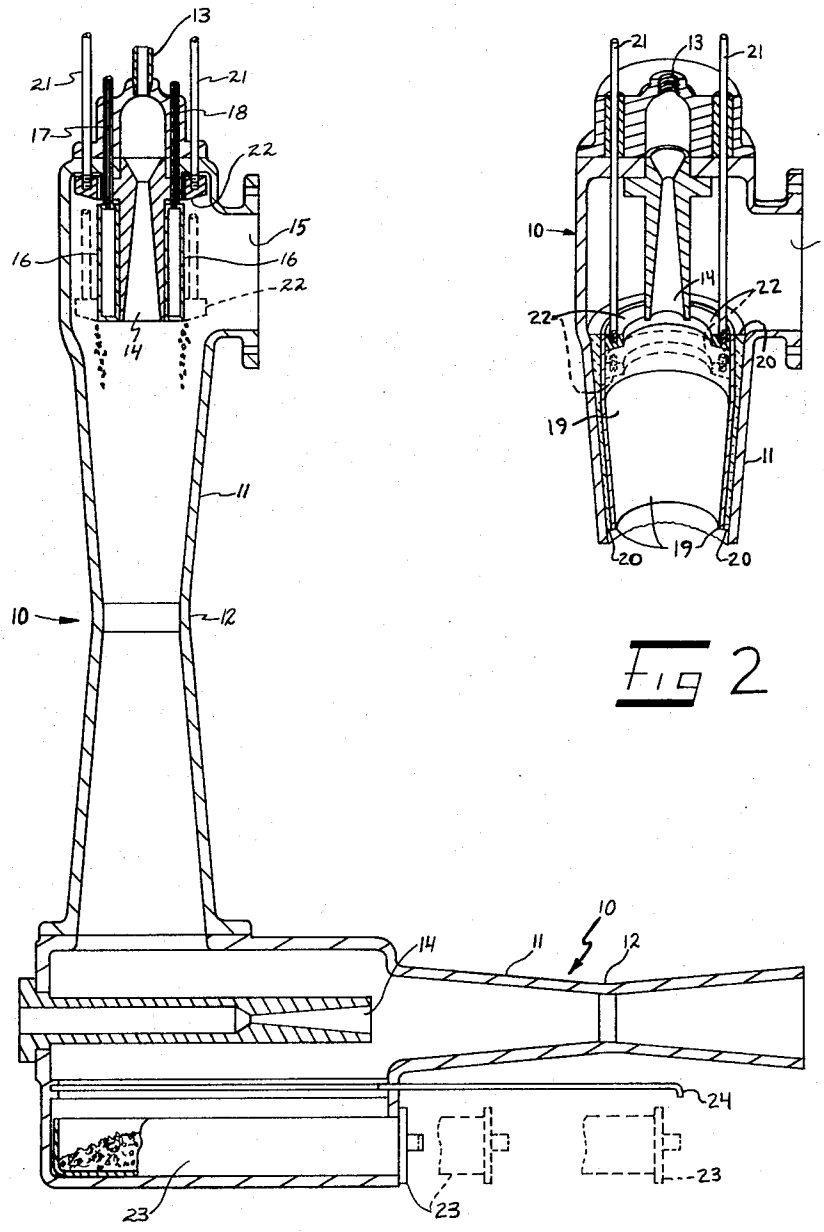


Fig 3

Fig 2

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COLD TRAP ICE-REMOVAL MEANS FOR VACUUM DRYING SYSTEMS

This invention relates to ice removable means and more particularly to devices for preventing ice accumulations on cold traps used in conjunction with vacuum chambers.

In the past, cold traps have been installed in vacuum process chambers to accumulate and thus remove condensable vapors therefrom. The purpose of such operations may be to remove vapors from a product thus drying it, to reclaim condensable vapors, or a combination of the two. This vapor removal reduces the load on the vacuum pump or ejector system by reducing the total volume of gas-vapor mixture expelled. This freezing out of the condensable vapors in the chamber increases the efficiency of the system and in the case of steam jet pump ejectors, reduces the amount of steam required in the evacuation process.

Considering, as an example water vapor removal, it has, up to now, been necessary to periodically cease operation of the drying system to allow accumulated ice on the cold trap to melt and be removed since the accumulated ice buildup insulates the trap from the chamber atmosphere thus reducing the trap's efficiency of operation. This insulating effect of accumulated ice can even reach the point of rendering the trap for all practical purposes useless. Periodic shutdown of the system to remove accumulated ice in essence causes the drying process to be a batch process and eliminates any real possibility of a practical, continuous operation, vacuum drying system.

If removing ice from the cold trap and then from the vacuum chamber by dropping it through the evacuation system while at low subatmospheric pressure has been considered, the idea would have been discarded as impracticable due to the theory that ice particles passing through the evacuation pumps or ejectors would break or interrupt the vacuum thus completely defeating the intended purpose.

After much research and study into the above-mentioned problems, the present invention has been developed to allow either periodic or continuous mechanical removal of ice accumulations from the cold trap within a vacuum chamber or its evacuation system without interrupting the operation of the drying process. This improved and practical system is simple in theory of operation, is inexpensive to implement and is highly efficient. It allows maximum vapor removal from the products being dried while at the same time places a minimum load on the evacuation pumps or ejectors.

It is an object, therefore, of the present invention to provide a means for preventing excessive accumulation of ice on the cold trap of a vacuum-type moisture removal system.

Another object of the present invention is to provide in at least one stage of a multistage chamber evacuation system, a means for removing moisture from such stage by freezing and means for disposing of the frozen product.

Another object of the present invention is to provide a multiplicity of moisture removing means in various stages of a multistage evacuation system whereby vapor load on such system may be drastically reduced.

An additional object of the present invention is to provide a means for removing, on a continuous operation basis, condensed vapor from the interior of a low-pressure chamber used for vacuum drying of a product.

Another object of the present invention is to provide a system for removing ice accumulations from the cold trap of a vacuum drying system and melting such ice so that it may be removed by pumping.

Another object of the present invention is to provide a mechanical means for removing ice from a cold trap-type vapor accumulator, particularly when used in conjunction with a vacuum-type drying chamber.

Other objects and advantages of the present invention will become apparent and obvious from a study of the following description and the accompanying drawings which are merely illustrative of the present invention.

In the drawings:

FIG. 1 is a cutaway perspective of a steam jet ejector for evacuating and maintaining a low subatmospheric pressure within a chamber, including a cold trap and an ice removing means;

FIG. 2 is a modified cold trap with ice removing means;

FIG. 3 discloses, in schematic form, one type of system with which the present invention may be used; and

Fig. 4 is a modified system using the principles of the present invention.

With further reference to the drawings, a standard steam jet ejector indicated generally at **10** is disclosed which can be of the type produced by Graham Manufacturing Company, Inc., of Batavia, New York, wherein a frustoconical shaped housing **11** terminates in a necked-down portion **12**. To operate the ejector, superheated steam is introduced through steam inlet pipe **13** connected to a source of steam (not shown) at one end. The other end of this pipe terminates in jet nozzle **14**.

A vacuum line **15** communicatively connects a vacuum chamber (not shown) to the stream jet evacuation ejector.

Even though it could be located at any point back of the steam jet nozzle or even in the vacuum chamber itself, the cold trap **16** is preferably mounted in the general area adjacent such nozzle. A standard refrigeration cycle could be used to cool the cold trap and would include a coolent inlet line **17** and a coolent outlet line **18**. This system can be either of the type wherein the coolent is dropped to the desired temperature and circulated through the cold trap or it can be the type wherein a refrigerant is pumped into the cold trap which acts as an evaporator in a standard refrigeration system. For the purposes of this application, the first mentioned method of cooling will be shown and described rather than the latter system although it is to be understood that either will work adequately.

In addition to the above-indicated cooling systems for cold traps, a third means to freeze out and recover condensable vapors within the vacuum system using a steam jet pump or ejector is to place a heat conductive metal sleeve, such as that indicated at **19** of FIG. **2**, partially in the steam stream. This sleeve is insulated from the housing **11** by a collar **20** of non-heat conducting material and projects backstream from the steam jet as seen in the Figure. Even though the superheated steam within line **13** is approximately 500° Fahrenheit, the steam jet or ejector stream is between −5° and −60° Fahrenheit. This cold temperature is transmitted by the heat conductive sleeve into the area upstream of the jet stream and is of such a temperature as to freeze out condensable vapors in such area.

One or more scraper arms **21** are provided with a scraper blade **22** attached thereto. These scraper blades are disposed adjacent the exterior of either the cold trap **16** or the cooled, heat conductive sleeve **19**. As frost or ice accumulates from condensable vapors being frozen out of the atmosphere upstream from the ejector nozzle, the arms **21** can be activated to flake off and remove such accumulations.

Since the accumulated ice will immediately begin to revaporize when removed from the cold trap by the scraper blades, a means to remove such ice from the vacuum area must be utilized. Although it is possible to place an ice trap within the fall area of a horizontally disposed ejector, this is not considered commercially feasible or practical in light of the present invention.

Through experimentation, it has been found that ice particles falling into and through the jet stream ejector will not break the vacuum as heretofore believed. Because of this, it is not necessary to place the ice removal system in the high-vacuum area upstream of the first jet since the ejector can easily be disposed vertically so that the ice as it is removed from the cold trap will fall into such stream and be ejected thereby. In the next succeeding stage, the ice can be mechanically removed by means such as a catch pan **23** and a removal door **24**, particularly as seen in FIG. **3**. It may be pointed out, however, that leaving the ice to sublime (or to evaporate if heat is added) in the second or a later stage is possible since the vapor load caused by the ice at this point is much less important than in the first stage.

An alternate system to the above-described means for removing scraped ice would be similar to that disclosed in FIG. 4 wherein the first four steam jet ejector stages of a six to seven stage system are disposed vertically. Because of the vacuum conditions found at the end of the fourth stage of such a system, condensed, frozen ice particles scraped from a cold trap in the first stage will become liquefied at the end of the fourth stage. At this point a pump, indicated schematically at 25, can be utilized through a control valve 26 to remove the liquid from the system without breaking the vacuum therein. Also, all of the later stages following the fourth stage can be disposed horizontally since there is no further need for vertical disposition.

In the above, it is understood that, in a specific application, the number of stages preceding "liquid" conditions may vary, as well as the number and disposition of intercondensers.

To motivate the scraper arm or arms 21 to cause the blade 22 to remove the ice from the trap 16, any means may be used from a simple manually operated mechanism to an automatic means such as a double acting cylinder, a concentric and piston-type rod, a cam and guide means, or the like. Since all of these motivating means, as well as many other types, are well known in the art, a detailed description of their operation is not deemed necessary. The only area in which care must be taken is to maintain the vacuum within the chamber particularly in the area where the arms or motivating means pass thereinto.

The cold trap has been indicated usually as being disposed within the first or most upstream steam jet ejector since it has been found that by removing a majority of the vapor at this stage reduces the load and thus steam requirements in all of the subsequent stages. This does not mean, of course, that cold traps could not with advantage be located in the second or subsequent ejector stages. The reason, or course, that the load on the system is greatly reduced by removal of condensable vapors from the vacuum chamber and subsequent ejector stages is that they constitute the major residual gas in such chamber during the vacuum drying process.

In actual operation of an evacuation system of the type disclosed, high-pressure, superheated steam is forced out through the steam nozzle 14 to form a steam jet. This jet, acting as an ejector, pulls down a substantial vacuum upstream therefrom. This upstream area is connected through a vacuum line 15 to a suitable vacuum drying chamber (not shown). Connected in series to the first steam ejector can be up to seven additional ejectors, each being slightly smaller than the succeeding one. This type system is adequate to remove moisture in the freeze or vacuum drying process of food-type products, or to remove condensable vapors in many other types of vapor removal processes.

The one or more cold traps placed upstream from the first, and possibly succeeding steam ejector stages, accumulate by condensation the majority of residual vapor within the low-pressure portion of the vacuum system. As this condensed vapor builds up in the form of frost or ice on the cold trap or traps, it is cut loose by the motivated scraper blades and is allowed to fall from the ejector by gravity through the steam jet stream.

In the embodiment disclosed in FIG. 3, the loosened ice is either removed without breaking the vacuum as is possible by using a series of airtight chambers or compartments or it is removed with only an almost instantaneous break in the second stage of the evacuation system. In the system disclosed in FIG. 4, there is no need for the vacuum to be at any time broken since the liquefied, melted ice can be pumped off with no breach of airtight integrity.

From the above, it is obvious that the present invention has the advantage of converting what has heretofore been a batch process of vacuum or freeze drying of products into a continuous process which never requires total shutdown of the vacuum system to remove condensed vapors therefrom The present invention also has the advantage of requiring only slight modification to evacuation systems presently being used to convert them from a batch process system to a completely automatic system with constant removal of the condensed vapors as they accumulate.

The present invention may, or course, be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced herein.

What is claimed is:

1. A condensable vapor removal means for vacuum drying systems comprising: a chamber; at least one steam jet-type ejector having a steam jet stream emitted therefrom to evacuate said chamber to subatmospheric pressure; a cold trap means mounted within the area of said chamber comprising a temperature conductive member disposed partially within said steam jet stream and extending into said evacuated chamber whereby low temperatures may be transmitted from said stream into said chamber to freeze condensed vapors therein; and means to remove the freeze condensed accumulations from said trap whereby improved vacuum drying may be accomplished.

2. The removal means of claim 1 wherein the means to remove the accumulations from said trap is a mechanical scraper mounted juxtaposed thereto.

3. The removal means of claim 2 wherein the scraper means is continuously motivated during the drying process.

4. The removal means of claim 2 wherein the scraper means is periodically motivated.

5. A condensable vapor removal means for vacuum drying systems comprising: a chamber; at least one steam jet-type ejector having a downwardly, generally vertical disposed steam jet stream emitted therefrom to evacuate said chamber to subatmospheric pressure; a cold trap means disposed within the area of said chamber above and upstream from said jet; means to lower the temperature of said trap means below the freezing point of vapors within said chamber; means to remove freeze condensed accumulations from said trap means; and means for collecting the removed freeze condensed accumulations from the downstream side of said jet whereby said accumulations will be removed from said chamber area without interrupting the vacuum therein by falling through said jet stream.

6. The removal means of claim 5 wherein a plurality of steam jet ejectors are placed in series to evacuate said chamber.

7. The removal means of claim 6 including a multiplicity of said jet ejectors being disposed vertically in series; and pump means operatively connected to at least one of the downstream stages of said ejector system whereby when said removed frozen accumulations melt in said later stages, the liquid residue may be pumpingly removed from said system.

8. The removal means of claim 1 wherein a plurality of steam jet ejectors are placed in series to evacuate said chamber.

9. The removal means of claim 8 including a multiplicity of said jet ejectors being disposed vertically in series, and pump means operatively connected to at least one of said downstream stages of said ejector system whereby when said removed frozen accumulations melt in the later stages, the liquid residue may be pumpingly removed from said system.

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