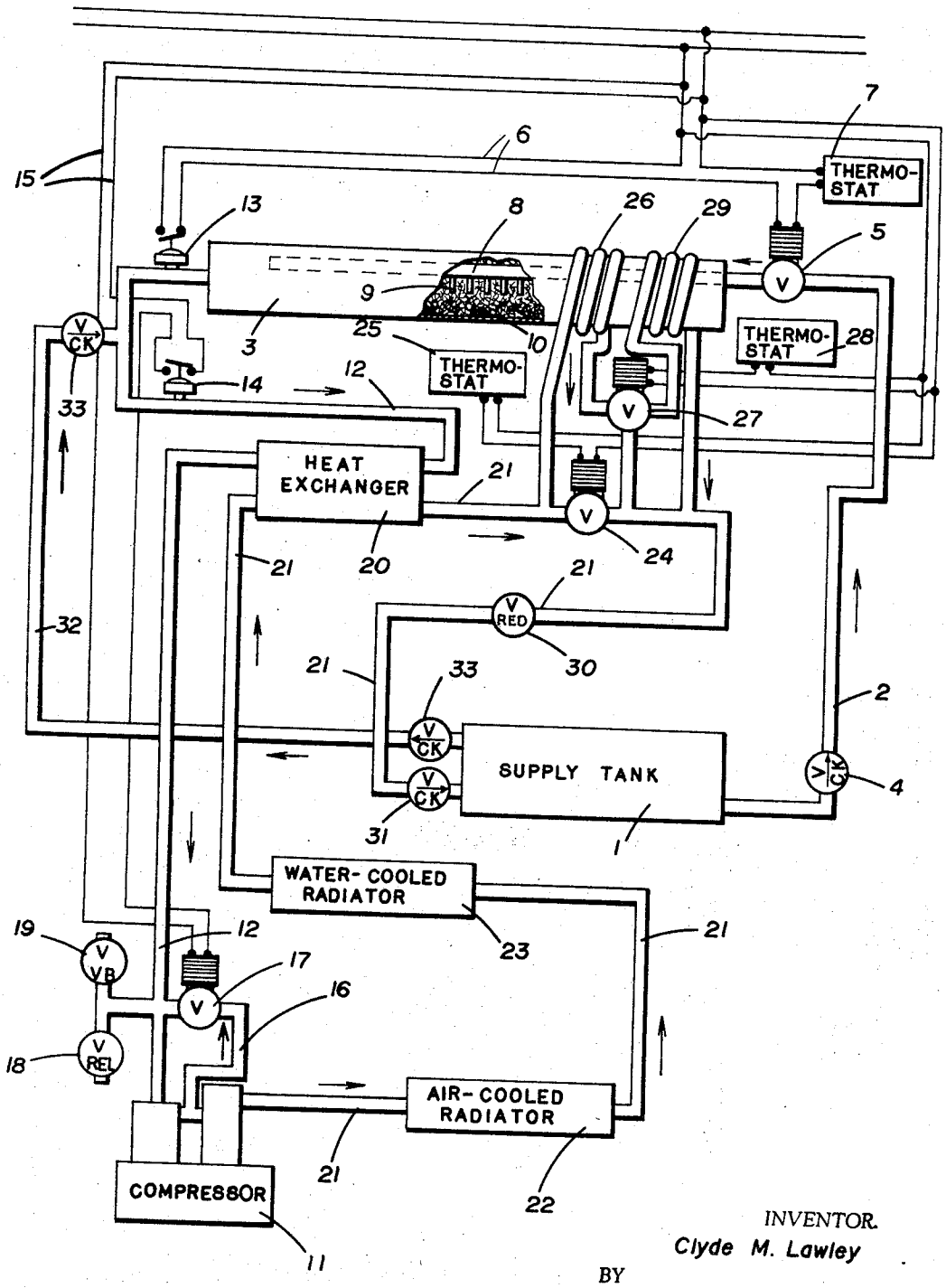
Feb. 18, 1969

C. M. LAWLEY

3,427,814

HEAT REMOVAL PROCESS

Filed April 6, 1967



INVENTOR.
Clyde M. Lawley

BY

Webster & Webster
ATTORNEYS

United States Patent Office 3,427,814
Patented Feb. 18, 1969

3,427,814

HEAT REMOVAL PROCESS

Clyde M. Lawley, 3320 John Lee Lane,
Modesto, Calif. 95350

Filed Apr. 6, 1967, Ser. No. 628,947
U.S. Cl. 62—48 5 Claims
Int. Cl. F25b 17/08; F25d 17/00

ABSTRACT OF THE DISCLOSURE

A heat removal process, for refrigeration or freezing operations, which is best defined as an enclosed, continuous acting, carbon dioxide cycling process; such process being carried out by an electro-mechanical system which will cycle—on demand—the carbon dioxide from a liquid state to Dry Ice, to its gaseous state, and then back to such liquid state.

Background of the invention

The present invention is the result of substantial experimental and development activity on my part seeking a low-temperature and hence quick-acting process of refrigeration or freezing.

Summary of the invention

The present invention provides, as its mapor object, a novel process premised essentially on the conversion of high pressure, liquid carbon dioxide into Dry Ice, with such Dry Ice confined as by a tube in the area (such as a refrigerating or freezing chamber) being subjected to temperature reduction and from which confinement the carbon dioxide upon return to a gas is recirculated and reused.

The present invention provides, as another object, a novel electro-mechanical system for the practice of the aforesaid process, and which system obtains an efficiency not obtainable with other pressure-expansion type heat removal processes.

The present invention provides, as an additional object, a heat removal process, and method of its practice, designed for ready and economical adaptation to sundry refrigeration or freezing operations.

The present invention provides, as a further object, a practical and reliable, and yet relatively simple, heat removal process, and method of its practice.

Brief description of the drawings

The figure of the drawing is a diagram illustrating the system employed in the improved heat removal process.

Description of the preferred embodiment

Referring now more particularly to the drawings and to the characters of reference marked thereon, the steps of the process of the present invention, and the equipment or apparatus employed in such process, comprise the following:

A supply of liquid carbon dioxide (CO_2) is stored in a suitable closed tank **1**, which may be either of a low or high pressure type. A low pressure tank if used is filled at approximately 300 p.s.i. at a temperature of zero degrees F., while a high pressure tank if used is filled at approximately 800 p.s.i. at a temperature of 70 degrees F. A liquid withdrawal or refrigeration supply pipe **2**, which will operate according to temperature demands, is connected to and leads from the tank **1** to one end of a relatively large diameter, elongated closed-end refrigeration tube **3**, which is located in the container or chamber in which the products or articles to be refrigerated or frozen are disposed. Interposed in the pipe **2** adjacent the tank **1** is a one-way or check valve **4**, opening away from the tank. Interposed in said pipe **2** adjacent the refrigeration

tube **3** is a solenoid-operated valve **5**, the solenoid of which is interposed in an electric supply circuit **6** having a thermostat **7** therein. This thermostat is positioned and related to pipe **2** so as to respond to the temperature therein.

Projecting into the refrigeration tube lengthwise adjacent the top and for substantially the full length of said tube is an extension **8** of the pipe **2**. A row of small diameter jets **9** depend from said extension **8** in the tube **3**; such jets discharging into metallic, heat conducting material **10**, such as steel wool or the like, with which the tube **3** is substantially filled.

The refrigeration tube **3** is suitably maintained at atmospheric pressure, or under a condition of vacuum, and as the liquid carbon dioxide—fed under pressure from pipe **2**—issues from the jets, it becomes mainly Dry Ice snow but with some gas; the gas being caused by instant heat absorption due to the heat transfer effect of the heat conducting material **10** into which the carbon dioxide is sprayed. If atmospheric pressure is maintained in the refrigeration tube **3**, the temperature of the refrigerant in the tube will be about —109 degrees F. If, on the other hand, a condition of vacuum is maintained in such tube **3**, the temperature of the refrigerant can be as low as —140 degrees F., depending on the amount of vacuum. The heat conducting material **10** carries heat absorbed from the walls of the tube **3** and transfers it to the interior of the tube, where such heat is given up to the refrigerant.

The gaseous carbon dioxide is withdrawn from the tube **3** at the end thereof opposite the pipe **2** by a compressor **11**, to the first stage of which a pipe **12** leading to the tube **3** is connected.

Interposed in the pipe **12** adjacent the tube **3** is a pressure-controlled switch **13**. This switch, which functions to cause opening or closing of valve **5**, is interposed in circuit **6**, and hence is subject to the action of thermostat **7**.

Also interposed in pipe **12** beyond the switch **13** is a vacuum-controlled switch **14**, having its own circuit **15**. Extending from the pipe **12** at a point between the switch **14** and the compressor **11** and connected to the latter between the first and second stages thereof, is a by-pass pipe **16** having a solenoid-operated by-pass valve **17** therein. The solenoid of valve **17** is interposed in the circuit **15** so as to be opened or closed by the functioning of the vacuum-controlled switch **14**. The pipe **16**, when valve **17** is open, allows the gaseous carbon dioxide to leave the compressor **11** between the first and second stages thereof, and return again to the first stage so that too great a vacuum will not be created therein.

Pressure relief and vacuum breaker valves **18** and **19**, respectively, are connected in suitably spaced relation to each other in communication with the pipe **12**; these valves being vented to atmosphere to provide a safety feature in the event of malfunction of the controls.

The pipe **12** intermediate its ends passes through an antifreeze-type heat exchanger **20**, filled with a suitable antifreeze solution.

The gaseous carbon dioxide leaves the compressor **11** through a high pressure pipe **21** in which an air-cooled radiator **22** is interposed. Beyond this radiator, the pipe **21** passes through a water-cooled radiator **23**, and then carries the gas through the antifreeze-type heat exchanger **20**. Interposed in the pipe **21** beyond the heat exchanger **20** is a solenoid-operated by-pass valve **24**, the solenoid of which is activated by a suitably positioned, circuit-fed thermostat **25** responsive to the temperature in pipe **21** between heat exchanger **20** and valve **24**.

Depending on the setting of the valve **24**, and which depends on the temperature in pipe **21** adjacent but ahead of the valve **24**, the carbon dioxide in the pipe may flow directly back to the tank **1**, or through a coil **26** encircling the tube **3**, and which coil is connected at its intake end

to said pipe 21 immediately ahead of the valve 24. Upon leaving the coil 26, the confined carbon dioxide encounters a solenoid-operated valve 27; the solenoid of which is activated by a suitably positioned, circuit-fed thermostat 28. This thermostat is responsive to the temperature adjacent the discharge end of coil 26. Depending on the setting of valve 27, the carbon dioxide may flow directly back to the tank 1, or be diverted and passed through another tube-surounding coil 29 which feeds back to the pipe 21 beyond the valve 24; a pressure-reducing regulator 30 being interposed in said pipe 21 at a suitable point between the coil 29 and the tank 1. Adjacent the tank 1, a check valve 31, opening toward the tank, is interposed in the pipe 21. It may be noted that the valve 24 is set so that even when open, it creates a small amount of restriction which will cause any part of the carbon dioxide which is still in its gaseous state to flow through to coil 26.

A vapor-balance pipe 32 leads from the tank 1 to a connection with the pipe 12 at a point between the switches 13 and 14; one-way or check valves 33, both opening away from the tank 1, being interposed in the pipe 32 adjacent its ends.

In the practice of the process, by the above described system, and to recapitulate somewhat, the liquid carbon dioxide in the tank 1 leaves the same under its initial pressure through the pipe 2 and, passing through the check valve 4 and thermostatically controlled valve 5, enters the refrigeration tube 3 through the supply pipe extension 8 and is sprayed by jets 9 into the heat conducting material 10; the jets being of small size to eliminate any pressure drop within them. As such heat conducting material 10 picks up heat from the walls of the tube 3, the carbon dioxide when sprayed onto said material by the jets 9—while initially mainly in the form of Dry Ice snow—absorbs the heat and becomes a gas; such heat absorption being rapid, effective, and producing the requisite low temperature effect in the container or chamber in which the tube 3 is disposed. The carbon dioxide gas then passes from the tube 3 into the pipe 12, being drawn to the compressor 11 by the action thereof; the gas passing the pressure-controlled switch 13 and then the vacuum-controlled switch 14 before reaching the compressor 11.

It should be noted that the pressure-controlled switch 13 is wired to open or close the valve 5 on the feed pipe 2, while the vacuum-controlled switch 14 is wired to open and close the solenoid valve 17 on the by-pass pipe 16.

The gas, beyond the vacuum-controlled switch 14, passes through the heat exhanger 20 and absorbs heat therefrom, passing thence to the compressor 11. After being compressed, the now high-pressure gas passes along pipe 21 and through the air-cooled radiator 22 where part of the heat is removed from the compressed gas. The gas is then passed through the water-cooled radiator 23 which removes more heat from the gas. The gas thereafter passes through the heat exchanger 20, in separated relation to the passage of gas in the pipe 12 therethrough, whereby the gas gives up still more of its heat.

The gas, continuing along the pipe 21, then encounters the thermostat-controlled, solenoid-operated by-pass valve 24 in its path. If the gas is still not cold enough to return to a liquid condition, the valve 24 will be operated to cause the gas to pass through coil 26 surrounding refrigeration tube 3. Returning from the coil 26, the gas encounters the thermostat-controlled, solenoid-operated valve 27, and if the gas has then returned to a liquid state said valve 27 will be operated to allow the liquid to return to the pipe 21, and pass therethrough back to the supply tank 1. If, however, the carbon dioxide when reaching the valve 27 is still not cold enough to become liquified, said valve will be operated to cause the gas to pass through the other tube-surrounding coil 29 to complete the reliquifying process and so that the carbon dioxide—restored to its initial liquid condition—then returns through the pipe 21 to and enters tank 1 for further cycling through the system. Before returning to tank 1, the liquified carbon dioxide passes, of course, through regulator 30 and check valve 31.

The vapor balance pipe 32 is a safety feature against excessive pressure building up in the tank 1. Any such excessive pressure will be automatically relieved (without any loss of carbon dioxide) by passing without interference through said pipe 32 and back into the pipe 12 between the switches 13 and 14; the check valves 33 in pipe 32 insuring against any back flow.

While only a single refrigeration tube 3 has been shown in the present instance, a number of such tubes—disposed in side-by-side parallel relation and each having a jet extension 8 manifold-fed from the one supply pipe 2—may be employed as a unit.

An important feature of the present invention resides in the fact that the Dry Ice snow when formed, and which serves as the actual refrigerant, is confined within the refrigeration tube (or tubes) 3 so that the evaporated gases may be returned through the pipe 12 to the tank 1 for recycling; the walls of the tube 3, of course, absorbing the heat away from the container or chamber holding the products or articles which it is desired to cool, freeze, dry, or shrink.

When used for food refrigeration or freezing, it is believed that the present process, and system for its practice, will greatly upgrade the quality of the food-stuffs. The faster freezing action assured by this process eliminates cell rupture, and decreases oxidation and bacterial action. Foods thus quick-frozen, at the low temperatures available, retain their fresh appearance, firmness, aroma, and taste when subsequently thawed.

The use of this process is, of course, not limited to food refrigertion or freezing, and such process can be readily adapted to many other fields of use.

If the system is employed in an adaptation wherein such system will be subject to recurrent periods of shutdown and which would allow undesirable warming of the anti-freeze solution in the heat exchanger 20, an auxiliary refrigeration unit may be provided for said heat exchanger and arranged in association with the cooling section of the latter.

From the foregoing description, it wil be readily seen that there has been produced such a heat removal process as substantially fulfills the objects of the invention, as set forth herein.

While this specification sets forth the present and preferred details of the heat removal process, still in practice such deviations from such details may be resorted to as do not form a departure from the spirit of the invention, as defined by the appended claims.

What is claimed is:

1. An enclosed, continuous acting, carbon dioxide cycling process providing refrigeration by means of a system including a tank holding liquid carbon dioxide under pressure, a pressure-tight refrigeration enclosure, a supply pipe leading from the tank to the enclosure, the latter having a quantity of heat conducting material therein in substantial contact with a wall of said enclosure, an extension of the pipe within the enclosure having a plurality of jets directed toward said material and adapted to jet-discharge the liquid carbon dioxide into substantially all thereof, a compressor, a second pipe leading from the enclosure and adapted to deliver gas from the latter to the compressor, a heat exchanger through which said second pipe passes between the enclosure and compressor, a third pipe leading to the tank from the compressor, and cooling devices interposed in said third pipe at intervals in its length.

2. A process, as in claim 1, including means to bypass at least one of said cooling devices in response to the temperature in said third pipe at a predetermined point therein.

3. A cycling process for utilizing initially liquid car-

bon dioxide as a refrigerant in a pressure-tight refrigeration enclosure comprising the steps of continuously feeding the liquid carbon dioxide under pressure to the enclosure, providing a quantity of heat conducting material in the enclosure in contact with a wall thereof, spraying the liquid carbon dioxide within the enclosure into said material whereby the sprayed carbon dioxide initially transforms in the main to Dry Ice snow and then to gas upon absorption of heat from said material and the enclosure, withdrawing the gas from said enclosure, compressing the carbon dioxide gas subsequent to withdrawal from the enclosure, subjecting the compressed gas to the action of a cooling medium to cause the gas to reliquify, and then recycling such liquified carbon dioxide.

4. A cycling process for utilizing initially liquid carbon dioxide as a refrigerant in a pressure-tight refrigeration enclosure comprising the steps of continuously feeding the liquid carbon dioxide under pressure to the enclosure, providing a quantity of heat conducting material in the enclosure in contact with a wall thereof, spraying the liquid carbon dioxide within the enclosure into said material whereby the sprayed carbon dioxide initially transforms in the main to Dry Ice snow and then to gas upon absorption of heat from said material and the enclosure, withdrawing the gas from said enclosure, compressing the carbon dioxide gas subsequent to withdrawal from the enclosure, passing the compressed gas through a heat exchanger to remove heat from said gas, thereafter testing the compressed gas for temperature, and if such temperature is insufficient to cause the compressed gas to reliquify

then subjecting the compressed gas to another cooling medium to further reduce said temperature.

5. A cycling process for utilizing initially liquid carbon dioxide as a refrigerant in a pressure-tight refrigeration enclosure comprising the steps of continuously feeding the liquid carbon dioxide under pressure to the enclosure, providing a quantity of heat conducting material in the enclosure in contact with a wall thereof, spraying the liquid carbon dioxide within the enclosure into said material whereby the sprayed carbon dioxide initially transforms in the main to Dry Ice snow and then to gas upon absorption of heat from said material and the enclosure, and withdrawing the gas from said enclosure; said heat conducting material substantially filling the enclosure, the latter being elongated, and the liquid carbon dioxide being jet-sprayed into said heat conducting material along substantially the entire length of the elongated enclosure.

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LLOYD L. KING, *Primary Examiner.*

U.S. Cl. X.R.

62—64