Dec. 17, 1963 P. A. MacLEAN 3,114,247

CRYOGENIC PUMP FOR A REFRIGERATOR SYSTEM

Filed July 6, 1960 2 Sheets-Sheet 1

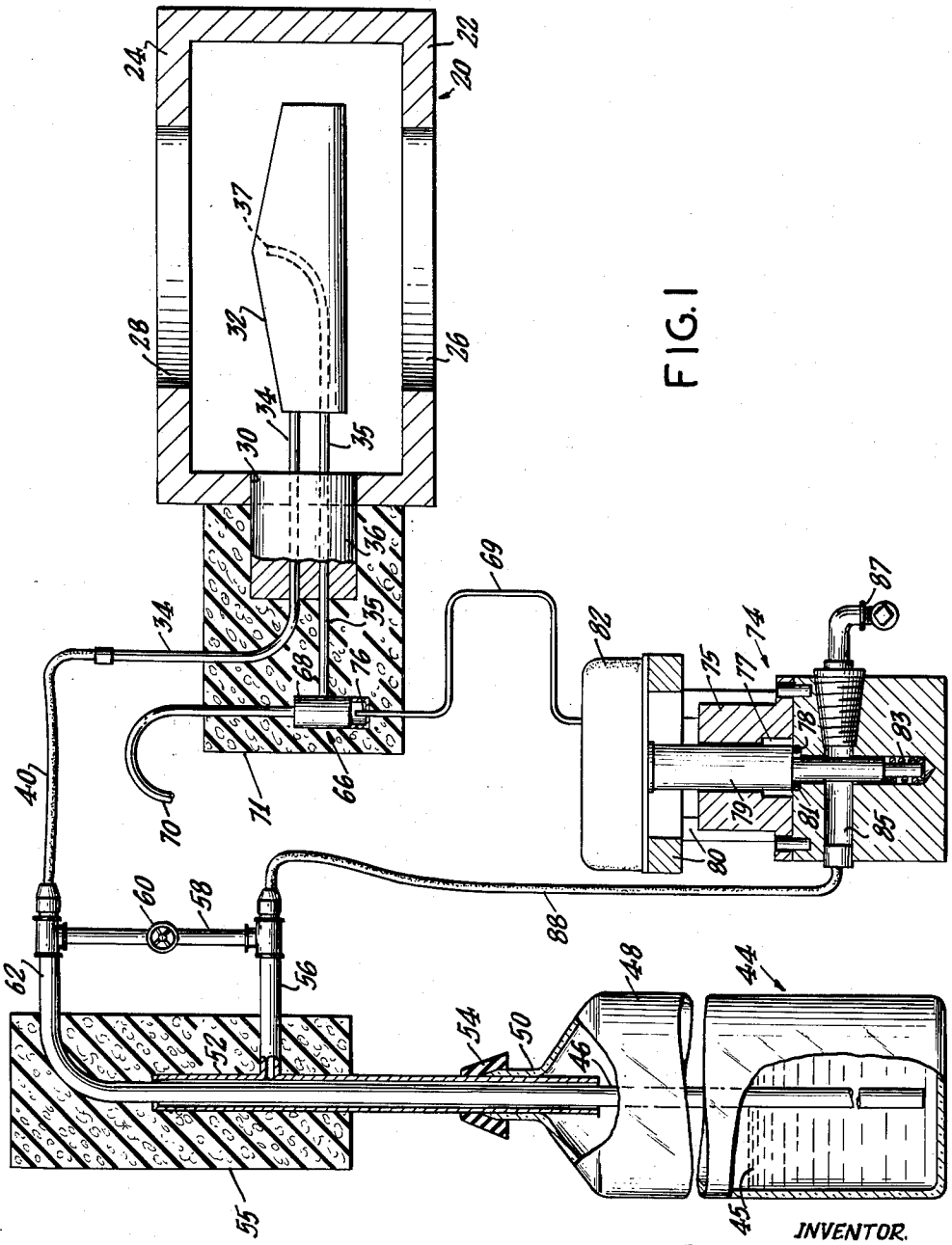

FIG. 1

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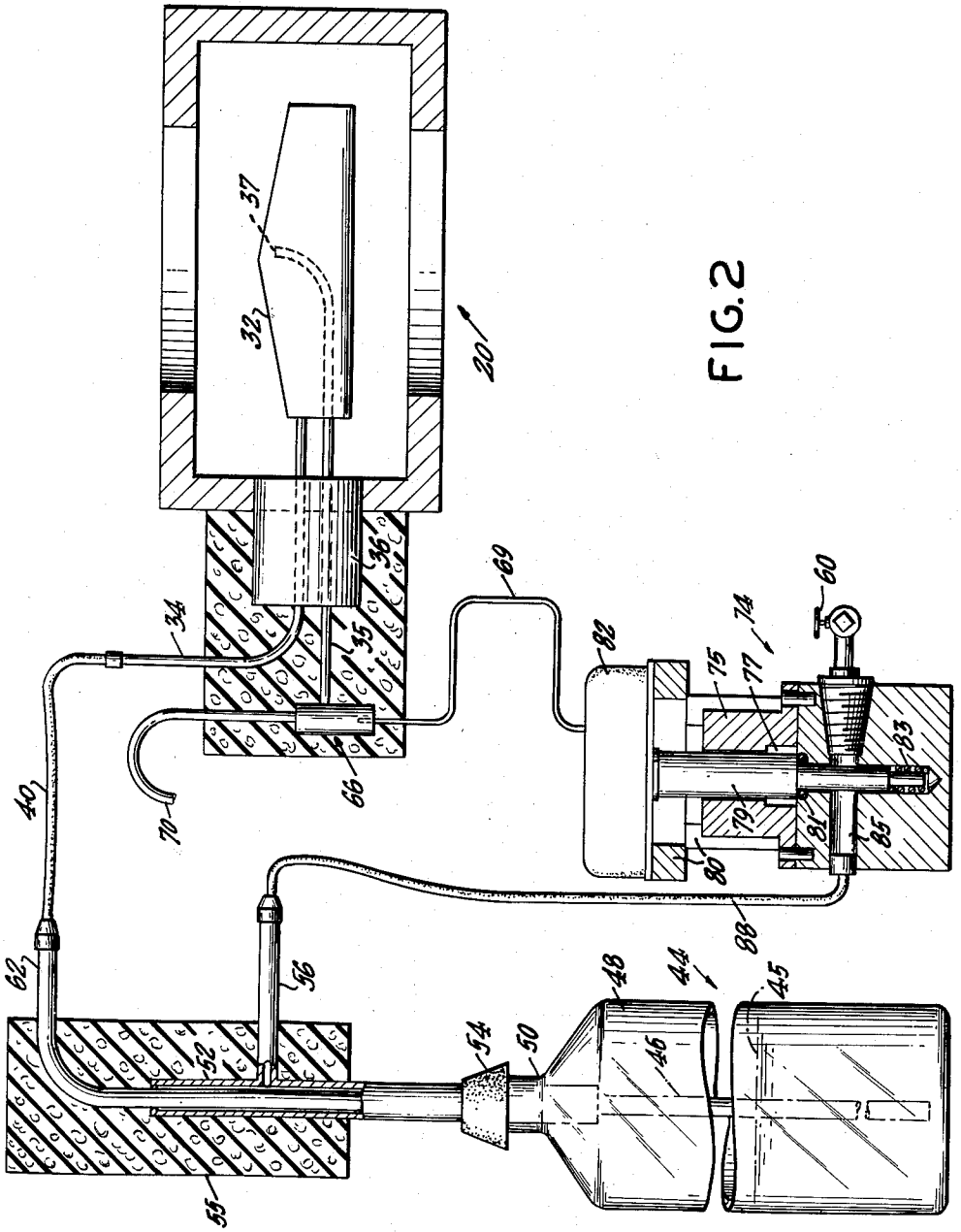

FIG. 2

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CRYOGENIC PUMP FOR A REFRIGERATOR SYSTEM

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6 Claims. (Cl. 62—51)

This invention relates to a cryogenic pump. The invention has particular reference to a system wherein a hollow cold trap evaporator is injected into a partially evacuated chamber for the purpose of condensing on the outer shell of the evaporator, vapors and gases which remain within the partially evacuated chamber and thus further reduce the pressure in the chamber. The cold trap evaporator is filled with liquid nitrogen or similar liquefied gas which cools the shell of the cold trap whereby condensation of vapors is accomplished.

It is an object of this invention to provide a cold trap system wherein the cold trap evaporator is continuously filled with a liquefied gas or similar coolant.

It is a further object of the invention to provide a cold trap system wherein the cold trap evaporator is continuously supplied with liquefied gas under pressure in an efficient economical manner without waste and wherein the liquefied gas is supplied only during those periods in which the evaporator is not full and wherein the liquefied gas supply is cut off when it overflows out of the evaporator.

In accordance with the invention there is provided in a cold trap system, a source of liquefied gas, a cold trap evaporator adapted for communication with an evacuated chamber for condensing on the evaporator gases from the chamber, pipe means for conducting the liquefied gas to the evaporator, overflow means in the evaporator extending out of the evaporator, and means responding to the liquefied gas from the overflow means for preventing further flow of liquefied gas from the source.

Further objects of the invention and the invention itself may be best understood by considering the following detailed description, which may be read in connection with the accompanying drawings wherein several embodiments of the invention are described.

In the drawings:

FIG. 1 is a schematic showing of a cryogenic pumping system which embodies the principles of this invention.

FIG. 2 is a variation of FIG. 1.

Referring to FIG. 1, a cylindrically shaped cold trap body 20 is integrally united above and below with a pair of annular end plates 22 and 24 which define circular openings 26 and 28 respectively. Centrally positioned within the body 20 there is provided a hollow conical thin-walled cold evaporator 32 which is sealed for holding a continuous supply of liquid refrigerant. The cold evaporator extends through peripheral opening 30 (in the body 20) and communicates with a rigid liquid-coolant supply tube 34 and with an interiorly projecting, rigid overflow tube 35 which terminates at the apex of evaporator 32 with an open end 37. The tubes 34 and 35 serve to support the evaporator and pass through a removable segment 36, secured to the body 20 by known means. The segment 36 is removable specifically for the purpose of allowing entry and removal of the evaporator 32 into the body 20 to tightly hold the lines 34 and 35 so as to adequately support the evaporator 32. The coolant used may be liquid air, liquid nitrogen, or any other liquefied gas which is suitable for cooling purposes. The liquefied gas in the evaporator 32 serves to cool the outer surface of the evaporator and results in condensation of vapors upon its surface thereof. Suitable means not shown support

the open end 37 of the tube 35 near the apex with just sufficient clearance near the apex to permit flow of liquefied gas or pressurized gas from the evaporator 32 into the tube 35 when the liquid reaches level of the interior end 37 of tube 35 near the evaporator apex. When the liquid level from the supply tube 34 lies below the open end 37 of tube 35, rapidly evaporating coolant gases escape through the tube 35.

A flexible liquid-coolant-conducting line 40 communicates at one end with the tube 34 and at the other end with a siphon tube 46 of a liquid coolant storage flask generally designated 44. The storage flask 44 seals liquefied gas 45 under pressure to a level such as shown and serves, by means of the siphon tube 46, which extends below the liquid level within the flask, to charge the evaporator 32 with liquefied gas through the flexible liquid conducting line 40 secured to the tubes 34 and 46. The pressurized gas within the flask forces the liquefied gas upwardly through the tube 46 and into the evaporator 32.

The flask 44 includes the storage bottle portion 48 having a neck 50, a capped gas control tube 52 which telescopes from the flask neck 50 to which it is secured by a gas tight pressure-sealing rubber cap 54, a gas conducting pipe 56 communicating with the peak of the control tube 52, the siphon tube 46 projecting through the top of the control tube 52 and communicating directly with the liquid in the bottle 48, and a valve holding check pipe 58 connecting pipe 56 to the siphon tube 46. Suitable lockfoam insulation 55 is provided around the tube 52. A choke valve 60 mounted on the check pipe 58, when open, allows communication between an end 62 of the siphon tube 46, the control tube and the gas containing portion of the bottle 48, and thus serves to allow the pressurized gas in the bottle to pass out of tube 40 and hence through the trap. When closed, the valve 60 causes the liquid nitrogen in the flask 44 to be forced through the siphon tube 46, if the pipe 56 is otherwise closed.

The flexible liquid line 40 secured to the siphon end 62 serves to conduct liquid coolant when the valve 60 is closed, or gaseous coolant when the valve 60 is open, to the tube 34 so as to fill, when valve 60 is closed, the evaporator 32 with liquid coolant gas to the level determined by the interior level of the end 37 of the tube 35. Liquid reaching this level is passed out of the overflow tube 35 to a temperature sensitive control generally designated 66.

The control 66 is comprised of an upper cylindrical liquid-draining vertical tube 68 communicating at upper end thereof with an arcuate gas exhaust tube 70, at its periphery with the tube 35, and at the lower end with a temperature sensing tubulation element 76 projecting above the end of the tube 68. A block of lockfoam insulation 71 mounted on the side of the trap body 20 wholly encases the vertical cylinder 68 and serves to otherwise securely support the control members.

A temperature responsive pressure release valve generally designated 74 is operated by the control 66 and includes a valve body section 75 having an inlet port 85, an outlet port 77 communicating with the ambient air, a valve seat 78 and a valve stem 79 which when forced into engagement with the valve seat 78 prevents flow of gas from inlet port to outlet port; such flow being otherwise prevalent. A gas filled chamber forming normally expanded bellows 82 is secured to the valve body 75 by members 89 and when normally expanded forces the valve stem 79 against a sealing ring 81 in the valve seat 78 against the force of an expansion spring 83. The interior of the bellows 82 is connected at the top by means of metal tubulation 69 to the element 76. Contraction of the bellows occurs when liquefied gas surrounds the

element 76 and cools the gases within the bellows, resulting in upward movement of the valve stem 79 and subsequent disengagement from the corresponding valve seat 78. The pressure release valve 74 is opened in this manner. A flexible tube 88 connects the fluid passage within the valve 74 to the pipe 56 and allows passage of the gaseous coolant through the valve 74 from the flask 44 and prevents pressure from forcing liquid through the siphon, and the evaporator 32. Valve 74 is secured directly to the trap body 20 by means of the valve body 75 in a perferred embodiment of the invention.

When the overflow tube 35 no longer passes liquid nitrogen to the control 66, as a result of liquid not being pumped into the evaporator 32, the gas in the chamber 80 warms and the bellows 82 expand, lowering the stem 79 and closing the valve 74. Pressure build-up then resumes in the flask 44 so as to pump more liquid gas into the evaporator 32 until the bellows 82 are again caused to contract.

A safety release valve 87 set, for example, to twice the normal pumping pressure is provided in the pressure release valve to prevent damage to equipment in the event of a freeze-up in the lines, for example.

In operation when the system is started up, the choke valve 60 is open so that only gas will pass through the system. The gas, being dry, will clear away any moisture and so prevent freeze-up. To start pumping, the pressure release valve 74 and the choke valve 60 are closed. This prevents escape of gas from tube 52 causing pressure to build up in the flask 44, and forcing the liquid through siphon tube 42 through the liquid line 40 into the cold trap evaporator 32. When the evaporator is full, the liquid will flow through the overflow tube 35 into the control element 66. The gas that precedes the flow of liquid will escape through the exhaust tube 70 while the liquid will fall down into the tube 68 until the liquefied gas in the evaporator is lower than the end 37 of the overflow tube 35. The element 76 is connected to the tubulation 69 which extends to the gas filled bellows 82. When the liquid falls down around the tubular element 76, it cools the gas in the bellows system causing the bellows to contract; thus opening the pressure release valve. This ends pressure build-up in the flask 44, hence stopping the flow of liquid from the flask.

When the element 76 warms up allowing the bellows to expand, the release valve is again closed and the pumping cycle is started anew.

In the event the system becomes clogged, such as by freezing up, the increase of pressure opens the safety valve and prevents damage which may otherwise arise from excess pressure.

FIG. 2 represents a less detailed alternate system which is identical to the system of FIG. 1, except for the position of the choke valve 60 and the fact that check pipe 58 is no longer used. In this embodiment of the invention the choke valve 60 is mounted in the position formerly occupied by the safety release valve 87. The function of the choke valve 60 in this position is identical to that in FIG. 1. In the embodiment of FIG. 2, the choke valve 60, when closed, prevents escape of gas from the gas line 56 and causes pressure build-up in the flask 44 as long as valve 74 is closed. This allows the control element 76 to independently regulate the pressure release valve 74 so as to intermittently release gas through the outlet port 77. When open, the choke valve 60 provides an alternate outlet for gases and prevents pressure build-up in the flask 44. In this manner the evaporator 32 is continuously filled with liquid coolant while using the coolant most efficiently and without waste.

The foregoing detailed description has been given for clearness of understanding only and no unnecessary limitations should be understood therefrom, for modification will be obvious to those skilled in the art.

What is claimed is:

1. A cold trap system comprising a flask enclosing liquefied gas under pressure, siphon means extruding into the liquefied gas in said flask for expelling from said flask liquefied gas, conduit means in communication with the pressurized gas in said flask, control valve means connected with said conduit means adapted to release pressurized gas from said flask, and render said siphon means inoperative, a cold trap evaporator defining an enclosed chamber adapted to be maintained continuously at a maximum level of liquefied gas, tubular means for conducting the liquefied gas from said siphon means to said cold trap evaporator upon shutting off of said control valve, an overflow pipe in said evaporator for conducting from the top of said evaporator a fluid discharge, temperature sensitive means located to receive the fluid discharge and connected to said control valve means for shutting off said valve means upon receiving pressurized gas and for opening said valve upon receiving liquefied gas.

2. A cold trap system as in claim 1 wherein said temperature sensitive means includes gas filled expandable bellows, said bellows being effective to contract and open said valve means upon communcation with liquefied gas.

3. A cold trap system as in claim 2, wherein said temperature sensitive means further includes a control tube, an insulating sleeve surrounding said control tube, said tube being connected to said overflow pipe, tubulation means extending into the bottom of said tube and connected with said bellows, whereby when liquefied gas falls around the portion of said tubulation extending into the bottom of said lower tube said bellows contract and an exhaust tube connected to the top portion of said control tube to permit the escape of any gases.

4. A cold trap system for condensing gases, comprising a flask for holding liquefied gas under pressure, siphon means in said flask responsive to the pressure in said flask and extending from below the level of the liquefied gas to the outside of the flask for pumping the liquefied gas from the flask, control valve means outside said flask communicating with the interior of said flask above the level of the liquified gas for releasing the gas in said flask upon opening of said valve, whereby upon said valve being open no liquefied gas is pumped and liquefied gas is pumped when said valve is closed, a cold trap evaporator adapted to be placed in a vacuum chamber for condensing gases on the outer surface thereof, conduit means from said siphon means for filling said evaporator with liquefied gas upon said valve being closed, an overflow pipe extending from the top interior of said evaporator to the outside of said evaporator, for conducting gas and liquefied gas overflow from said evaporator, an open control cylinder outside of said bulb communicating with said overflow pipe for receiving the overflow from said evaporator, a bottom portion of said control cylinder positioned for receiving liquefied gas overflow, an insulating sleeve connecting said control cylinder, temperature responsive expandable means connected to said valve means for closing said valve means upon said expandable means being expanded by warming and for opening said valve means upon said expandable means being contracted by communication with a liquefied gas, a tubulation member connected at one end to said bottom portion of the control cylinder adapted to contact with said liquefied gas overflow and connected at the other end to said expandable means.

5. A system as in claim 4 further comprising selectively closable choke valve means communicating with said siphon means and the portion of said flask above the level of said liquefied gas for equalizing the pressure on said siphon means when said choke valve means are open, whereby liquefied gas is pumped by said flask upon said choke valve means being closed and pressurized gas is pumped upon said choke valve means being opened.

6. A cold trap system for maintaining continuously a

maximum amount of liquefied gas in an evaporator comprising:

a container of liquefied gas under pressure;

siphon means extruding into the liquefied gas in the container for expelling from said container liquefied gas;

an evaporator;

conduit means connected to said siphon means for carrying the liquefied gas to within the evaporator;

a liquefied gas overflow pipe within the evaporator and leading out of the evaporator; and

a liquefied gas flow control system to maintain continuously a maximum amount of liquefied gas within the evaporator, in fluid connection with said overflow pipe and responsive to the overflow of liquefied gas comprising a receptacle for receiving liquefied gas overflow, a gas conduit in communication with pressurized gas in the container, and a gas control valve connected to the gas conduit and the receptacle, and adapted to relieve the pressure within the container at predetermined times.

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