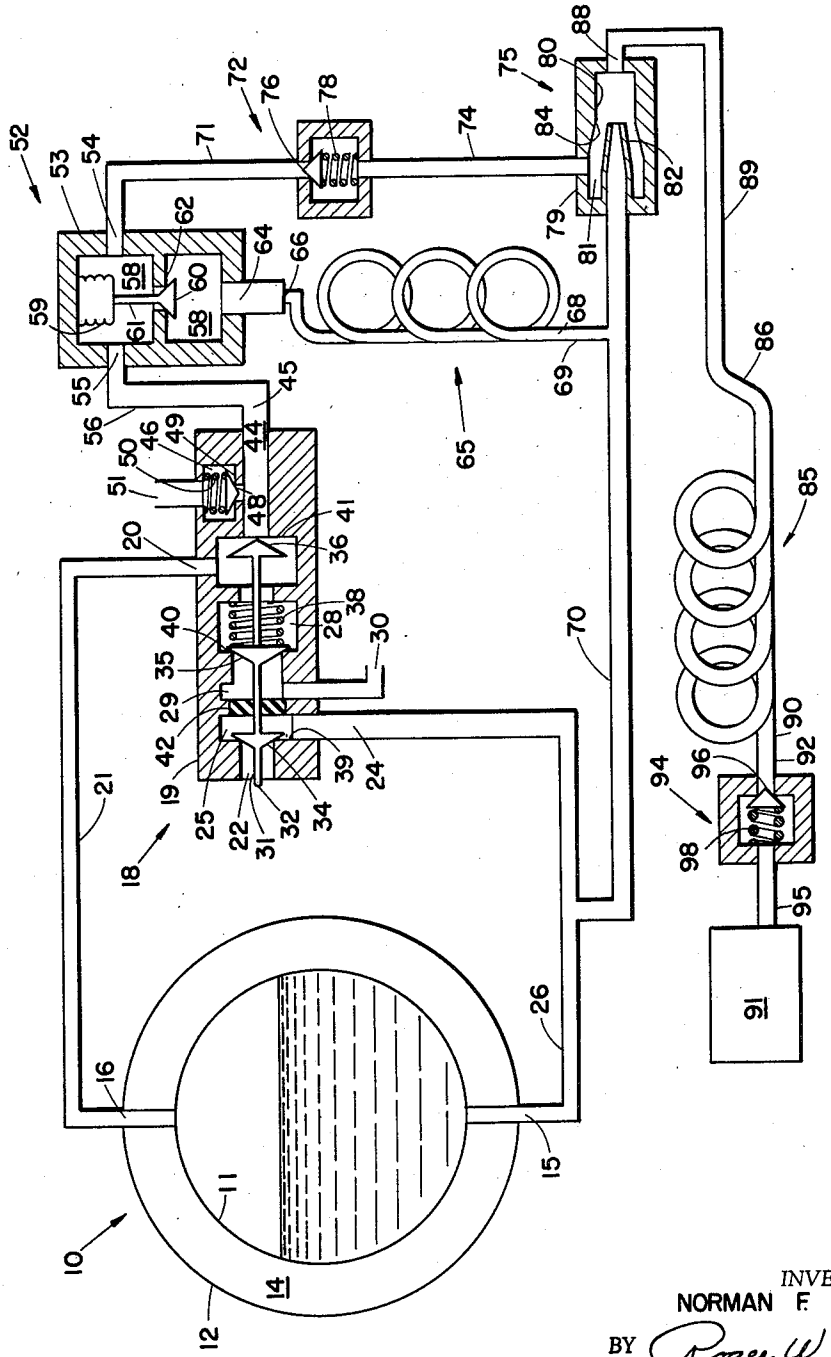
May 18, 1965 N. F. HOSFORD 3,183,678

LIQUID TO GAS CONVERSION SYSTEM

Filed April 29, 1963



INVENTOR.
NORMAN F. HOSFORD
BY Roger W. Nolan Jr.
ATTORNEY

United States Patent Office 3,183,678 Patented May 18, 1965

3,183,678

LIQUID TO GAS CONVERSION SYSTEM

Norman F. Hosford, Davenport, Iowa, assignor to The Bendix Corporation, Davenport, Iowa, a corporation of Delaware

Filed Apr. 29, 1963, Ser. No. 276,287
3 Claims. (Cl. 62—52)

This invention relates to a liquid to gas conversion system and, more particularly, to an improved and simplified liquid oxygen to gaseous oxygen conversion system of the economy type.

Liquid to gas conversion systems adopted for use as a supply for breathing oxygen may be divided into two broad classes, conventional systems and economy systems. Both systems, conventional and economy, are generally described in Patent Number 2,576,985, issued December 4, 1951, to William A. Wildhack. The present invention relates to the latter type. Present economy systems distinguish from conventional systems in the inclusion of an economy circuit which includes a valve generally described as a pressure opening valve. The advantages of an economy system over the conventional system appear in the conservation of oxygen during periods of non-use, but include the disadvantage of increased hardware to provide the economy function.

An object of the present invention is to provide an improved liquid oxygen to gaseous oxygen conversion system of the economy type.

Another object of the present invention is to provide an improved liquid oxygen to gaseous oxygen conversion system which maintains the functional advantages of an economy system while eliminating the standard economy circuit.

Present liquid oxygen to gaseous oxygen systems of the economy type include a pressure opening and a pressure closing valve whereby gas is drawn from the top of the liquid oxygen container when the pressure in the system is within a predetermined range of pressures. When the gas pressure in the system is above the range the gas is lost through a relief valve. Present systems, through the use of a check valve between the pressure opening and pressure closing valves, prevent liquid oxygen, trapped in the supply line during non-use, from returning to the liquid container, thereby wasting the liquid in the supply line as it is converted to gas, which gas pressurizes the container or is lost through the relief valve.

A further object of the present invention is to provide a liquid oxygen to gaseous oxygen conversion system, wherein trapped liquid oxygen in the supply circuit is returned to the liquid oxygen container.

A still further object of the present invention is to provide a liquid oxygen to gaseous oxygen system wherein the supply pressure can be maintained below the maximum pressure of the system.

A still further object of the present invention is to provide a liquid oxygen to gaseous oxygen system employing an injector economy circuit without a pressure opening valve.

A still further object of the present invention is to provide a liquid oxygen to gaseous oxygen system having a single operating pressure.

Certain of these objects are realized in the invention by the provision of a liquid container, means for converting liquid oxygen to gaseous oxygen at a rate commensurate with gaseous demand, means for preventing the reverse flow of fluid to the top of said container, and injector means permitting reverse fluid flow to the bottom of said container.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawing wherein an embodiment of the invention is illustrated. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description and is not to be construed as defining the limits of the invention.

The single figure of the drawing is a schematic diagram of one embodiment of the inventive liquid to gas conversion system.

Referring now to the drawing, the numeral 10 designates a liquid oxygen container having an inner wall 11 and an outer wall 12 forming evacuated chamber 14. Liquid port 15 is disposed at the bottom of container 10 and gas port 16 is disposed at the top of container 10.

Fill, build-up, vent, and relief valve 18 has valve housing 19 having gas outlet port 20 connected to gas port 16 of container 10 by means of tubing 21. Valve house 19 defines liquid fill port 22 and liquid port 24 which are connected by means of fill chamber 25. Liquid outlet port 24 is in communication with liquid port 15 of container 10 by means of tubing 26. Valve housing 19 further defines communicating build-up chamber 28 and gas vent chamber 29 which are in direct communication with gas port 20 and with gas vent 30, respectively. Valve stem 31 is disposed in liquid fill port 22 and extends through fill chamber 25, vent chamber 29 and build-up chamber 28. End 32 of stem 31 may be suitably designed for mating connection with any one of several suitable liquid oxygen fill nozzles. Fill valve head 34, vent valve head 35, and build-up valve head 36 are joined to and movable with stem 31. Valve stem 31 is biased in the build-up position (as shown) by means of spring 38, fill valve head 34 seats on valve seat 39 and liquid fill port 22 is closed off from fill chamber 25; vent valve head 35 seats on valve seat 40 and liquid vent chamber 29 is closed off from build-up chamber 28; build-up valve head 36 is off of valve seat 41. Fill chamber 25 is separated from vent chamber 29 by means of resilient seal 42. Valve housing 19 defines passageway 44 which is in direct communication with gas outlet port 20 and gas inlet port 45. Relief valve chamber 46 defined by housing 19 is in direct communication with passageway 44 and is intermediate gas outlet port 20 and gas inlet port 45. Relief valve head 48 is biased toward seat 49 by means of spring 50 to close off relief valve chamber 46 from passageway 44. Relief valve chamber 46 is in direct communication with exhaust port 51 which vents to the atmosphere.

Pressure closing valve 52 has a housing 53 having gas outlet ports 54 and 55. Outlet port 55 is in direct communication with gas inlet port 45 of fill, build-up, vent and relief valve 18 by means of tubing 56. Housing 53 defines pressure closing chamber 58 which is in direct communication with outlet ports 54 and 55. Pressure closing bellows 59 is disposed in pressure closing chamber 58 and is joined at one end thereof to the wall of chamber 58. Pressure closing valve head 60 is connected to the second end of bellows 59 by means of valve stem 61 and is biased away from pressure closing valve seat 62 by bellows 59. Housing 53 defines gas inlet 64 which is in direct communication with pressure closing chamber 58.

The numeral 65 designates a pressure build-up heat exchanger having a gas outlet 66 in direct communication with gas inlet 64 of pressure closing valve 52. Liquid inlet 68 is in direct communication with liquid port 15 of liquid oxygen container 10 by means of supply tubing 69 and 70 and tubing 26. The external build-up circuit thus comprises liquid port 15, tubing 26, 70, and 69, heat exchanger 65, pressure closing valve 52, tubing 56, fill, build-up, vent, and relief valve 18, tubing 21, and gas port 16.

The flow scheme for the improved liquid oxygen sys-

tem includes a novel economy circuit comprising gas port 16, tubing 21, fill, build-up, vent and relief valve 18, tubing 56, pressure closing valve 52, tubing 71, check valve 72, tubing 74, and venturi-injector 75. Check valve 72 includes valve head 76 which is biased in the position shown by means of spring 78; valve 72 is of the low pressure differential type for the purpose of preventing reversal of fluid flow to pressure closing valve 52.

Venturi-injector 75 includes a housing 79 which defines venturi 80 and aspirating chamber 81. Injector nozzle 82 is in fluid communication with liquid port 15 of container 10 by means of tubing 26 and 70 and extends through aspirating chamber 81 terminating at opening 84 of venturi 80. Aspirating chamber 81 is in fluid communication with pressure closing valve 52 by means of tubing 74, check valve 72, and tubing 71.

Supply heat exchanger 85 includes an inlet 86 which is in fluid communication with outlet 88 of venturi-injector 75 by means of tubing 89. Outlet 90 of heat exchanger 85 is in fluid communication with gas regulating device 91 by means of tubing 92, check valve 94 and tubing 95. Check valve 94 includes valve head 96 which is biased in the position shown by means of spring 98; valve 94 is of the low pressure differential type for the purpose of preventing reversal of fluid flow to heat exchanger 85.

For the purpose of illustrating the operation of the novel liquid to gas conversion system, various pressures will be used. These pressures are not to be construed as defining the limits of the invention; a wide range of pressures may be used which are within the scope of the novel liquid to gas conversion system.

In operation of the liquid to gas conversion system shown in the drawing when the system is to be used to supply breathing oxygen, liquid fill port 22 is connected to a suitable connector from a liquid supply. The connector from the liquid supply biases against valve stem 32 and moves fill valve head 34 off of seat 39, vent valve head 35 off of seat 40 and build-up valve 36 against seat 41. Fill, build-up, vent, and relief valve 18 is now in the "fill" position and the top of liquid oxygen container 10 is vented to the atmosphere through gas port 16, tubing 21, gas outlet port 20, build-up chamber 28, gas vent chamber 29, and gas vent 30. Liquid oxygen passes through inlet 22, fill chamber 25, liquid outlet port 24, tubing 26, and through liquid port 15 to fill liquid oxygen container 10. As the container 10 is filled with liquid, vaporized gas is vented through gas port 16 and to the atmosphere through gas vent 30. When the container 10 is full, liquid will pass out gas vent 30 and the connection can be removed from liquid fill port 22. Spring 38 biases fill valve head against seat 40, build-up valve head 36 off of seat 41. Fill, build-up, vent, and relief valve 18 is now in the "build-up" position as shown in the drawing.

With valve 18 in the "build-up" position there is direct external communication between the liquid and gaseous phases in the liquid oxygen container 10 by means of tubing 26, 70, and 69, heat exchanger 65, pressure closing valve 52, tubing 56, valve 18, and tubing 21. Through the force of gravity liquid passes through liquid port 15 of container 10 and into pressure build-up heat exchanger 65 and supply heat exchanger 85 by means of tubing 26 and 70, venturi-injector 75, and tubing 89. The liquid is vaporized in heat exchanger 65 and passes to the top of container 10 by means of valve 52, tubing 56, valve 18, and tubing 21; the liquid in heat exchanger 85 is vaporized and dispersed back through venturi-injector 75 and heat exchanger 65 and to the top of container 10. The increased volume of the gaseous oxygen in the system causes a pressure rise in the system which continues until a preset pressure of 75 p.s.i.g. (pounds per square inch gage) is reached. At 75 p.s.i.g. the pressure closing valve 52 will close as a result of the pressure collapsing pressure bellows 59. With pressure closing valve 52 closed, there is no further external communication between the liquid and gaseous phases of the liquid oxygen container 10 and liquid will not enter heat exchanger 65.

The liquid to gas conversion system is ready to supply oxygen gas to regulating device 91 when the pressure in the system is at or above 75 p.s.i.g. The check valve 94 is set to operate on a 5 p.s.i.g. pressure differential across valve head 96. When the pressure in tubing 95 drops to 5 p.s.i.g. below the pressure in tubing 92, the gas pressure tending to close valve 94 and the bias of spring 98 are overcome and valve head 96 will unseat allowing gas to flow to gas regulating device 91.

When there is no gas demand by the gas regulating device 91, pressure will continue to build up as the liquid in the system is vaporized. The build-up circuit is closed by means of pressure closing valve 52 as above described. The economy circuit (container 10, tubing 21, valve 18, tubing 56, valve 52, tubing 71, valve 72, tubing 74, venturi-injector 75, tubing 89, heat exchanger 85, tubing 92, valve 94, and tubing 95) is open and thereby provides a direct gas flow passage from the top of container 10 to gas regulating device 91. The gas pressure in the system will continue to build up until a gas pressure of 110 p.s.i.g. is reached when the relief valve portion of fill, buildup, vent and relief valve 18 will vent the gas to the ambient air and maintain the pressure in the system at a maximum of 110 p.s.i.g. The relief valve portion of valve 18 will open when the pressure in passageway 44 acting on valve head 48 overcomes the bias of spring 50 and the pressure at outlet 51.

An oxygen demand, as sensed by the regulating device 91 when the pressure in the system is between 75 and 110 p.s.i.g. will not alter the steady state of the system. The oxygen supplied will be the oxygen as represented by the pressure in excess of 75 p.s.i.g. The large percentage of the gas supplied to the regulator 91 when the pressure is between 75 and 110 p.s.i.g. will come from the liquid evaporated in the container 10. The gas will come directly from the container 10 to the regulating device 91 through the economy circuit; a small percentage of gas will be drawn through the injector 82 of venturi-injector 75.

As the demand for oxygen continues, the pressure in the system will drop to 75 p.s.i.g. at which point liquid oxygen will begin to flow through liquid port 15 of container 10. Substantially all of the oxygen gas will now be supplied from the liquid that is vaporized after leaving the liquid port 15. Any liquid which is vaporized in the container 10 will be supplied through the economy circuit. If the pressure in the system drops below 75 p.s.i.g. pressure closing valve 52 will open permitting the vaporization of liquid flowing into heat exchanger 65 to bring the pressure in the system to the operating pressure of 75 p.s.i.g.

At low demands for oxygen at regulating device 91 a low flow rate of liquid from container 10 occurs and the vaporization of the liquid will occur before the injector-venturi 75. At high flow rates liquid will flow through venturi-injector 75 and be vaporized downstream thereform. A stoppage of demand after a high flow rate will cause the liquid oxygen to be forced back through venturi-injector 75 to container 10.

While the liquid to gas conversion system as shown in the drawing is of the construction shown and described, it is understood that the instant invention is not limited to any particular form or construction. Moreover, other changes and modifications of the novel liquid to gas conversion system contemplated herein may be made by those skilled in the art without departing from the scope of the instant invention.

I claim:

1. An improved liquid to gas conversion system of the economy type comprising, a liquid storage vessel having

a liquid port and a gas port, supply line means in fluid communication with said liquid port for withdrawing liquid from said storage container at a rate commensurate with a gaseous demand, a gas line in fluid communication with said gas port, venturi-injector means in fluid communication with said supply line means and said gas line for directing the flow of gas from said gas supply line above a predetermined pressure, valve means for restricting the reverse flow of fluid from said venturi-injector means to said gas port.

2. An improved liquid oxygen to gaseous oxygen conversion system of the economy type comprising, a liquid oxygen storage vessel having a liquid port and a gas port, a pressure build-up circuit connecting said liquid port and said gas port and comprising in series a heat exchanger adjacent said liquid port, a pressure closing valve, a combination valve having a pressure build-up passage therethrough communicating with said gas port, a supply conduit in fluid communication with said build-up circuit intermediate said liquid port and said heat exchanger and including a venturi-injector means for controlling the flow of fluid therethrough commensurate with the fluid pressure in said system, an economy circuit in fluid communication with said gas port through said pressure closing valve and terminating in said venturi-injector, said economy circuit including a check valve means restricting the flow of fluid from said venturi-injector to said gas port.

3. An improved liquid oxygen to gaseous oxygen conversion system of the economy type comprising a liquid oxygen storage vessel having a liquid port and a gas port, a pressure build-up circuit connecting said liquid port and said gas port and comprising in series a heat exchanger adjacent said liquid port, a pressure closing valve having a valve seat, a cooperating valve head and a pressure chamber disposed above said seat, a combination valve having a pressure build-up passage therethrough communicating with said gas port, a supply conduit in fluid communication with said build-up circuit intermediate said liquid port and said heat exchanger and including a venturi-injector an economy circuit in fluid communication with said gas port through said pressure chamber of said pressure closing valve and terminating in said venturi-injector, said economy circuit including a check valve means restricting the flow of fluid from said venturi-injector to said gas port, said venturi-injector comprising an injector and a venturi in fluid communication with said economy circuit, said injector in fluid communication with said supply conduit having an end thereof disposed for injection into said venturi.

References Cited by the Examiner

UNITED STATES PATENTS

3,001,375	9/61	Tauscher	62—52
3,070,968	1/63	Gardner	62—52

ROBERT A. O'LEARY, *Primary Examiner.*