June 8, 1943. E. F. YENDALL ET AL 2,321,445

PROCESS OF AND APPARATUS FOR CONSERVING GAS MATERIAL

Filed June 20, 1941 2 Sheets-Sheet 1

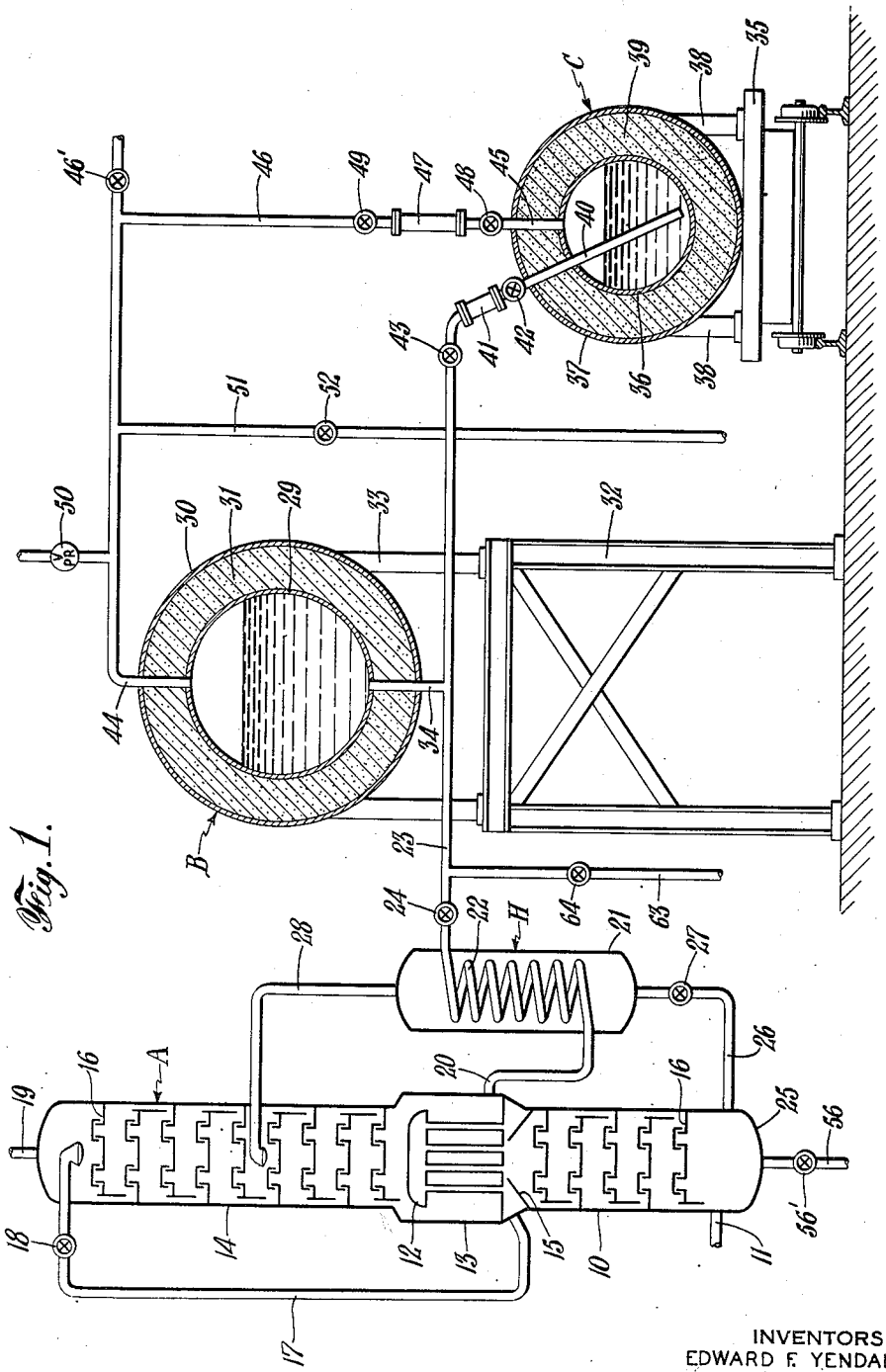


Fig. 1.

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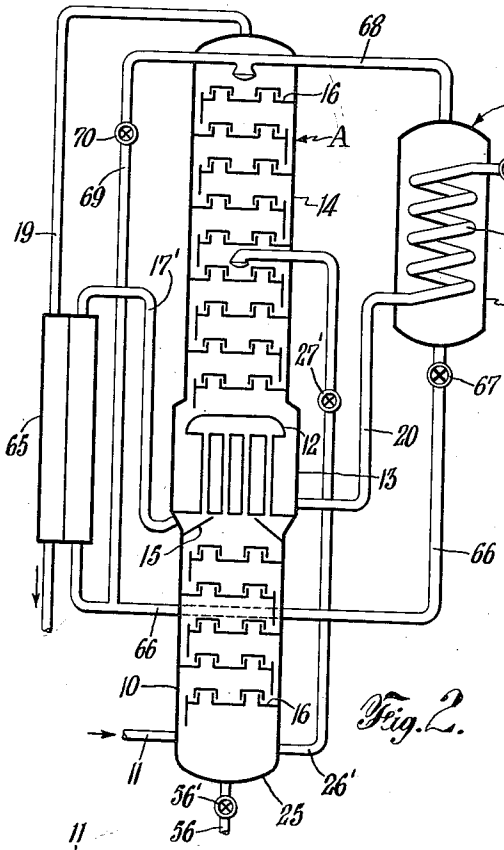


Fig. 2.

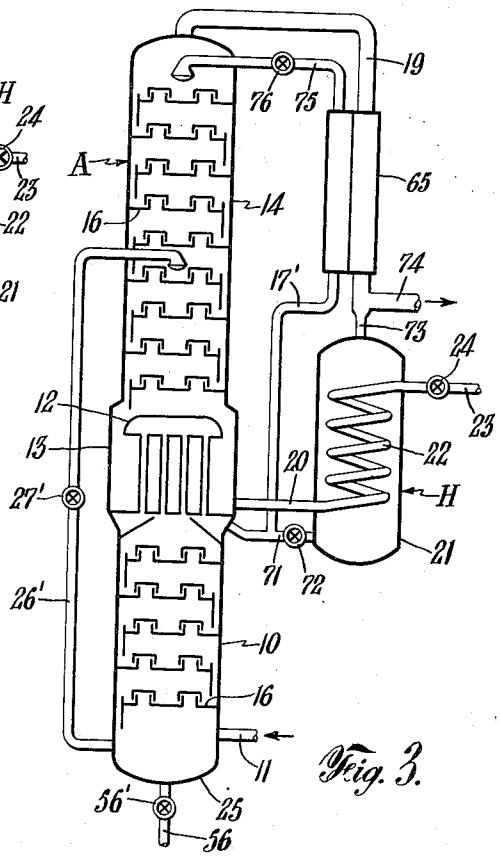


Fig. 3.

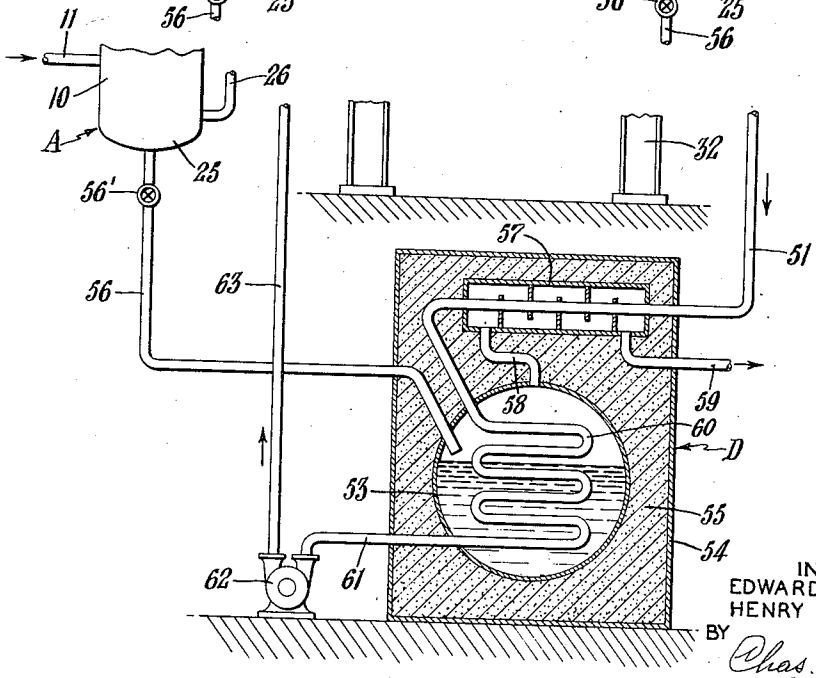


Fig. 4.

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PROCESS OF AND APPARATUS FOR CONSERVING GAS MATERIAL

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Application June 20, 1941, Serial No. 398,908

19 Claims. (Cl. 62—1)

This invention relates to a process of and apparatus for conserving a commercially valuable gas material in the liquid state, such gas material having a boiling point at atmospheric pressure below 273° K. The invention relates more particularly to a process of and apparatus for conserving liquid oxygen produced by the low-temperature rectification of air.

Liquid oxygen is customarily produced by the low-temperature separation of air including rectification in at least two stages. In such process the air to be rectified is compressed to a suitable high pressure, freed of undesirable constituents such as moisture and carbon dioxide, refrigerated to relatively low temperatures, and partially liquefied by countercurrent heat exchange with the nitrogen-containing product of the separation. The cooled and partly liquefied air is, in some cases, subjected to a preliminary treatment including washing of the vapor phase portions with the liquid phase portions before it is passed into the first or higher pressure rectification stage. In the first stage of rectification there is formed a liquid comprising more than 50% nitrogen and containing the major portion of the oxygen of the air and another fluid product comprising mainly nitrogen. Both these fluid products of the first stage are expanded to the pressure of the last stage of rectification and introduced at suitable portions of the last stage, the fluid containing mainly nitrogen being passed to the upper end of the last rectification stage so that the liquid portion thereof provides a reflux for the last stage. The liquid oxygen produced collects in and is withdrawn from the lower end of the last stage. It is customary to operate the high-pressure stage of rectification under a pressure of about 75 lbs. per square inch gauge and the last stage under a pressure of about 5 to 10 lbs. per square inch gauge. The liquid oxygen produced thus has a temperature equal to its boiling point corresponding to the pressure of the last rectification stage.

The liquid oxygen customarily produced is of commercial purity and contains about 99.6% oxygen, and unless otherwise specified the term "liquid oxygen" as used herein will refer to the liquid oxygen of commercial purity. The term "fluid" as employed herein is intended to include material in the liquid state, the gaseous state, or mixed liquid and gaseous states. When the liquid oxygen produced under a pressure of 5 to 10 lbs. per square inch is transferred into a receiving vessel such as a well insulated storage tank and it is desired to maintain the liquid oxygen in such tank at substantially atmospheric pressure, an appreciable portion of the liquid produced will flash into vapor. The amount of liquid flashed into vapor corresponds to the refrigeration required to cool the balance of the liquid to the boiling point temperature at atmospheric pressure. When the pressure drop is 8 lbs. per square inch, the amount of such loss may be about 4% of the liquid produced. It has also been proposed to operate the storage tank at substantially the pressure of the upper column and thus have available a pressure head for transferring the liquid from the storage tanks into transport tanks located at the same level as the storage tank. When such liquid is transferred into the transport tanks where it is to be held at atmospheric pressure, a portion of the liquid similarly flashes into vapor.

It has been proposed to save the gas so produced by compressing it into the customary high-pressure oxygen cylinders or by compressing such gas and passing it into the air-separation apparatus at a suitable point. The first method of conserving the gas loss requires the use of compressing and cylinder handling machinery which is not always available in a liquid producing plant and requires power for its operation, while the second method incurs the danger of contaminating the oxygen and interfering with the operation of the rectification apparatus.

When liquid oxygen is stored at atmospheric pressure or is shipped in insulated portable tanks under pressures substantially above atmospheric pressure, the normal unavoidable leakage of heat into such tanks causes a constant slow evaporation of some of the liquid which constitutes a further liquid loss. In the case of the portable tanks, it has been necessary to blow such gas to the atmosphere. It has been proposed to subcool the liquid oxygen to a temperature substantially below its boiling point at atmospheric pressure before it is put into the portable tanks so that the liquid can be maintained in the portable tanks for a desired period of time before heat leak will have warmed it to a temperature such that vaporization will continue after the maximum pressure to be maintained in the tank has been reached. Such sub-cooling, however, has been accomplished by the evaporation of a substantial portion of the liquid under a reduced pressure so as to cool the rest of the liquid and this results in a reduction of the liquid oxygen that can be shipped from the plant.

It is a principal object of the present invention to provide an improved process of and appa-

ratus for conserving a liquefied gas product such as liquid oxygen produced by low-temperature separation of a gas mixture such as air, by sub-cooling such liquid product before it is passed into the storage tank or receiving container. Other objects of the invention are to provide a process of and apparatus for sub-cooling liquid oxygen produced by the low-temperature rectification of air by effecting heat exchange of the oxygen product with a suitable low-temperature fluid drawn from the rectification stages; to control the degree of sub-cooling of the liquid oxygen by selecting the point from which the cooling fluid is drawn from the rectification stages and by selecting the pressure to which such fluid is expanded; to further control the degree of sub-cooling by proportioning the amount of cooling fluid employed for sub-cooling the liquid oxygen to the amount of liquid oxygen to be sub-cooled; to effect the sub-cooling of the liquid product by heat exchange with an expanded liquid drawn from the lower part of a higher-pressure stage of rectification; to effect the sub-cooling of the liquid product by heat exchange with a fluid removed from the upper part of a higher-pressure rectification stage to obtain deeper sub-cooling; for conserving any vapors generated in the receiving container by liquefying such vapors in heat exchange with a fluid drawn from the rectification stages and expanded to a lower pressure; and for transferring liquid oxygen from one container to another by gravity substantially without gas loss.

The above and other objects and novel features of the invention will be apparent from the following description taken with the accompanying drawings in which:

Fig. 1 is a sectional view schematically showing an exemplary apparatus for carrying out the invention, including means for sub-cooling the oxygen product by liquid drawn from the lower end of the high-pressure rectification stage and showing a stationary storage tank and a portable tank arranged according to the invention;

Figs. 2 and 3 are sectional views schematically showing two alternative arrangements of the apparatus for sub-cooling the oxygen product by employing a fluid drawn from the upper portion of the high-pressure stage; and,

Fig. 4 is a fragmentary sectional view of another portion of apparatus which may be employed in conjunction with the apparatus illustrated in Figs. 1, 2, and 3 for reliquefying vapors drawn from the tanks.

Referring now to the drawings, a two-stage air rectifying apparatus is illustrated generally at A. At B is generally indicated, a liquid oxygen storage tank for receiving the product of the rectifying apparatus. At C there is indicated generally a portable tank such, for example, as a railroad tank car connected to receive a supply of liquid oxygen from the storage tank B or the rectifying apparatus; and at D (Fig. 4) is shown generally a device for reliquefying vapors drawn from the tanks B and C.

The customary apparatus for compressing and refrigerating air and preparing it for admission to the rectifying apparatus A constitutes no part of the present invention and is not shown in the interests of clearness of the drawings. The rectifying apparatus A may be of the customary type having a lower column or high-pressure stage **10** into which the compressed and partly liquefied air is introduced through a conduit **11**. The upper end of the column **10** is provided with a condenser **12** surrounded by the liquid oxygen chamber **13** which forms the lower end of the upper column **14**. The lower column **10** is provided with a liquid collecting shelf **15** arranged to receive a portion of the liquid produced by the condenser **12**, such liquid being the result of the condensation of vapors passing from the upper end of the column **10** into the condenser **12**. Part of the liquid produced by the condenser **12** provides a reflux for the lower column so that the liquid collected on the shelf **15** contains very little oxygen. Both upper and lower columns **14** and **10**, respectively, are provided with suitable gas and liquid contact trays **16** in the customary manner. To provide reflux for the upper column **14**, the liquid collected by the shelf **15** is transferred to the upper end of the column **14** by a transfer conduit **17** provided with an expansion valve **18**. The nitrogen product of the rectification in the upper column which contains but very little oxygen passes out through the conduit **19** and the refrigeration contained therein is employed to cool the incoming air.

The oxygen product of the upper column which collects in the chamber **13** is withdrawn therefrom through a conduit **20** at a suitable rate so as to maintain a desired height of liquid in the chamber **13**. It was previously customary to pass the liquid withdrawn through conduit **20** directly to the storage tank B by gravity flow, the tank B being positioned at a low level. According to the invention, however, there is interposed in the liquid-oxygen discharge conduit, a heat exchanger indicated generally at H for sub-cooling the liquid. Such heat exchanger may have any suitable construction but is here shown as a chamber **21** having disposed therein a heat-exchange pipe coil **22**, the conduit **20** connecting with the lower end of the pipe coil **22**. The upper end of the pipe coil **22** is connected to the discharge line **23**, and, at that point there is interposed a control valve **24**.

The lower end of the column **10** is provided with a liquid collecting sump **25** in which is collected a liquid containing most of the oxygen of the air admixed with a large portion of liquid nitrogen. The proportion of oxygen in such liquid is substantially greater than the proportion of oxygen in air but the liquid still contains more than 50% nitrogen and is a liquid with a high-nitrogen content. It was customary to pass such liquid directly to the upper column for rectification therein. According to one embodiment of the invention, however, the chamber **21** of the heat exchanger H is connected to the sump **25** by a conduit **26** controlled by an expansion valve **27**, and from the upper end of the chamber **21** a conduit **28** conducts the fluid originating at the sump **25** into the upper column **14** at an intermediate point thereof. If the upper column is operated under a pressure of about 8 lbs. per square inch gauge, the liquid oxygen collecting in the chamber **13** will be at its boiling point at such pressure and have a temperature of −178° C. If such liquid oxygen were reduced to atmospheric pressure after passage through the valve **24**, about 4% thereof would flash into vapor. However, if the lower column is operating under a pressure of about 75 lbs. per square inch gauge, and the upper column at about 8 lbs. per square inch gauge, a part of the liquid drawn from the sump **25** and passed through the expansion valve **27** will flash into vapor and at the same time both the liquid and vapor will have its temperature reduced to a temperature that may be as low as −189° C. The liquid oxygen passing through the coil **22** can therefore be cooled to a temperature

approaching −189° C. Since the boiling point of liquid oxygen at atmospheric pressure is −183° C., it will be seen that a substantial degree of sub-cooling is attained and no flashing of liquid oxygen into vapor will occur due to the pressure reduction from 8 lbs. per square inch gauge to the pressure of the storage tank B.

The storage tank B may be of the customary construction including an inner liquid-holding vessel 29 surrounded by an outer shell 30 and having a relatively thick layer of heat-insulating material 31 between the vessel 29 and the shell 30. The tank B is preferably supported at a suitable elevation by a frame 32 and by columns 33 for mounting the shell 30 on the frame 32. The tank B is elevated sufficiently so that liquid may be discharged by gravity to the portable containers C. The discharge line 23 which, like other portions of the apparatus and pipe lines operating at low temperatures, is thoroughly heat insulated, is connected with the bottom of the vessel 29 by a conduit 34.

The portable tank C may be a tank mounted on a vehicle such as a railway car 35. The construction of the portable tank C is generally similar to the storage tank B and includes an inner vessel 36, an outer shell 37 provided with braces 38 supporting it on the car 35 and a layer of heat insulation 39 between the vessel and the shell. The tank C is also provided with a liquid filling and discharging line 40 which is connectable with the discharge line 23 by a flexible connector 41. Stop valves 42 and 43 are preferably provided adjacent either end of the flexible connection 41. The tanks B and C are preferably also provided with gas withdrawal connections 44 and 45 leading from the upper portions of the vessels 29 and 36, respectively, and connected together by a conduit 46, the conduit 46 being coupled to the connection 45 by a flexible connector 47. Stop valves 48 and 49 are provided adjacent the ends of the connector 47. The conduit 46 is also provided with a pressure relief valve 50 which is adjusted to release gas on the attainment of an excessive pressure in the tank B and a valved connection 46' that may be placed into communication with a gas holder if it should be desired to release gas to such holder to reduce the gas pressure in the system below that for which the safety valve 50 is set to operate.

In the event that the liquid in vessel 29 becomes warmed so that the pressure builds up to a pressure in excess of atmospheric pressure, or in the event that it is desired to recover gas contained in a portable tank C, gas may be withdrawn from the conduit 46 from either or both tanks B and C through a connection 51 controlled by a stop valve 52. The gas withdrawn through connection 51 may be conserved by reliquefying it by heat exchange with a fluid drawn from the rectification, for example, the gas may be liquefied in the liquefying device D illustrated in Fig. 4.

The liquefying device D may be in the form of any suitable heat-exchanging device. A preferable form, however, comprises a liquid storage vessel 53, which is surrounded by heat insulation 55 contained in an outer casing 54. The cooling liquid is supplied to the vessel 53 from any suitable point of the rectification apparatus A or from the air liquefying apparatus. A convenient source of cooling fluid is from the sump 25 of the rectifying apparatus. A conduit 56 controlled by a regulating valve 56' is connected to the bottom of the lower column 10 and arranged to pass liquid from the sump 25 into the vessel 53. The vessel 53 is preferably operated under substantially atmospheric pressure and since the pressure in the lower column 10 is substantial, it will be seen that a substantial head is available for the transfer of such liquid. Hence, the vessel D may be located at any suitable position, such for example, as at the level of, or above the tank B. For convenience, the location is here shown as below the frame 32.

Within the casing 54 is preferably located a gas-phase heat exchanger 57 through which the conduit 51 passes. The heat exchanger 57 has passages surrounding the conduit 51 for conducting the vapors discharged from the vessel 53 so as to effect heat exchange between such vapors and the gas passing through the conduit 51. A connection 58 conducts the vapors from the vessel 53 to the heat exchanger 57 and a connection 59 discharges the vapors to the atmosphere. It will be observed, however, that if desirable, the vapors discharged through conduit 59 could be conducted to a suitable point of the rectifying apparatus. A heat-exchange coil 60 is submerged within the liquid in the vessel 53 and has its upper end connected with the conduit 51 and its lower end connected by a conduit 61 to a pump 62. The discharge outlet of the pump 62 is connected by a conduit 63 to the discharge line 23. A stop valve 64 may be interposed in the conduit 63. By the pump 62 the liquid formed in the heat-exchange coil 60 may be transferred back to the tank B. If the reliquefying device D is placed at a sufficient elevation, the pump 62 could be omitted and the liquid produced in the coil 60 could be arranged to flow to the tank B by gravity.

In Figs. 1, 2, and 3 similar elements of the apparatus are designated by the same reference characters. Referring more particularly to Fig. 2, the liquid oxygen produced and passed through the heat-exchange pipe coil 22 is sub-cooled by a fluid which has a very high nitrogen content. Such fluid is obtained by arranging the conduit 17' which draws fluid including liquid from the shelf 15 of the lower column 10 to pass through a heat exchanger 65 to cool it by heat exchange with the cold outflowing nitrogen product conducted to the heat exchanger 65 through the conduit 19. The cooled shelf fluid is conducted by a conduit 66 to the lower end of the heat-exchanger chamber 21 which is here positioned at a higher level. Before entry into the chamber 21, the shelf fluid passes through an expansion valve 67. From the upper end of the chamber 21, the shelf fluid (liquid and gas) is passed to the upper end of the upper column 14 through the conduit 68. If desired, a portion of the shelf fluid may under special conditions be by-passed around the heat exchanger H through a by-pass conduit 69 connecting the conduit 66 with the upper end of the column 14. Conduit 69 is likewise provided with an expansion valve 70. In this form of the apparatus, the liquid collecting in the sump 25 of the lower column is transferred directly to the mid-portion of the upper column by transfer conduit 26' controlled by expansion valve 27'.

Another arrangement for employing shelf liquid for sub-cooling the coil 22 is illustrated in Fig. 3 in which such shelf liquid is directly conducted by a by-pass conduit 71 into the chamber 21, an expansion valve 72 being provided at the entrance to the chamber 21. The nitrogen effluent from the column 14 is conducted by the conduit 19 through the heat exchanger 65 from

which it is discharged at 14. The vapors produced in the vessel 21 by evaporation of shelf liquid therein pass out through connection 73 to join with the out-flowing nitrogen in conduit 14 so that the refrigeration contained therein may be usefully applied to cool the incoming air. Obviously, the conduit 73 could alternatively connect to conduit 19. The nitrogen transfer conduit 17' is preferably connected to the heat exchanger 65 for conducting shelf fluid thereto. Such shelf fluid is passed from heat exchanger 65 by a conduit 75 to the upper end of the upper column 14, the conduit 75 being controlled by an expansion valve 76.

In Fig. 3, and in Fig. 2, when the by-pass conduit 69 is employed, the flow through the valves 67 and 72 may be restricted and controlled to maintain a liquid level in the chambers 21 just sufficient to cover the coils 22, the remainder of the shelf fluid being passed through the conduits 69 and 17'. The maintenance of such liquid level is optional in the apparatus of Fig. 2 but is preferable in the apparatus of Fig. 3 to insure the passage of adequate reflux liquid to the column 14. In the apparatus of Fig. 2, the heat exchanger 65 operates in the customary manner for cooling the shelf fluid; a large amount of the gas-phase portion of the shelf fluid may be liquefied, and the entire shelf fluid cooled due to the low temperature of the effluent nitrogen leaving the upper column which, if the upper column pressure is 8 lbs. per square inch gauge, will be about —192° C. This temperature will be attained by the shelf fluid upon expansion through the valve 67 because the expansion is to the same pressure. The heat exchanger 65 insures that more of the shelf fluid will be in the liquid state after expansion. In the apparatus of Fig. 3, the expansion of a portion of the shelf fluid through the valve 72 also reduces its temperature to —192° C. although this temperature could be reduced still lower if the conduit 73 were arranged to discharge the vapor from chamber 21 to a portion of the apparatus operating at a lower pressure. By employing shelf fluid for sub-cooling, the temperature of the liquid oxygen, can readily be reduced to —190° C. and thus the liquid can be maintained in storage at the plant or, if desired, during transportation for a considerable period of time before its temperature is raised by heat leakage to —183° C., the boiling point at atmospheric pressure.

In the operation of the liquefier D, it will be evident that any suitable liquid having a boiling point at or below —183° C. can be employed in the vessel 53. Ordinarily such liquid is preferably taken from the sump 25 of the rectifying apparatus and withdrawn at a relatively slow rate so as not to disturb the operation of the rectifying apparatus. In cases where air is washed with portions of liquid air before entry into the rectifying column for the elimination of certain impurities, the liquid waste discharged to take away such impurities may be passed into the vessel 53. Also, various liquid wastes sometimes discharged from various other portions of the rectifying apparatus can be passed into the vessel 53. During periods when the rectifying apparatus is shut down, the liquid stored in the vessel 53 will be available for effecting the reliquefaction of vapors from the storage and transport tanks. When the rectifying apparatus is in operation, the portions of sub-cooled liquid oxygen continuously added to the storage tank B, mix with the liquid in the tank to cool the same and thus the normal heat leak is constantly being counteracted and the pressure in the tank can be maintained at a low value.

The sub-cooling of the liquid oxygen and the reliquefaction of vapors from the tanks represents a certain quantity of refrigeration taken from the rectifying apparatus and this must be balanced by added refrigeration work input which results in a slight increase in power cost. This increased power cost however is more than compensated for by the increased liquid oxygen output that can be delivered to the consumers.

In order to disclose the broad principles of the invention, several embodiments thereof have been illustrated and described. Obviously certain features of the invention can be used independently of others and changes may be made in various parts of the apparatus without departing from the essential principles of the invention. For example, although the conservation and dispensing of liquid oxygen has been specifically described, the principles of the invention may be employed for the conservation and dispensing of other commercially valuable gas materials in the liquid state.

We claim:

1. A process for conserving liquid oxygen produced by the rectification of air at low temperatures which comprises withdrawing a liquid having a substantial nitrogen content from the rectification; expanding such withdrawn liquid to a lower pressure; and effecting heat exchange between such withdrawn and expanded liquid and said oxygen product of the rectification to sub-cool said product to a temperature which is above the temperature of said expanded liquid and low enough to prevent vaporization of said liquid oxygen when passed into a receiving container.

2. A process for conserving liquid oxygen produced by the rectification of air at low temperatures which comprises passing the liquid oxygen produced by said rectification in heat exchange relation with a fluid drawn from said rectification, said fluid having a temperature below the boiling point of liquid oxygen corresponding to its pressure when passed into a receiving container controlling the rate of withdrawal of said fluid to cool said liquid oxygen to a desired temperature sufficiently low to prevent vaporization thereof in said receiving container; and conducting said fluid after said heat exchange to join the nitrogen product of said rectification.

3. A process for conserving oxygen produced by the low temperature rectification of air in stages at successively lower pressures, said oxygen product being produced in the last of said rectification stages at a pressure slightly above atmospheric pressure, which process comprises withdrawing a fluid having a substantial nitrogen content from a prior stage of the rectification; expanding such withdrawn fluid to at least substantially the pressure of the last of said rectification stages; passing said oxygen product in heat-exchanging relation with said expanded fluid to bring said oxygen product into the sub-cooled liquid state; and transferring such sub-cooled liquid oxygen into a receiving container wherein it is held under a pressure below that of said last stage of rectification.

4. A process for conserving liquid oxygen according to claim 3 in which said fluid comprises a substantially liquid product of the next to the last stage of rectification, and which includes the step of passing said fluid after said heat ex-

change with the oxygen product, to a portion of said last stage of rectification.

5. Process for conserving liquid oxygen according to claim 3 in which said fluid comprises the product of the next to the last stage of rectification having the least oxygen content, and which includes the step of conducting said fluid after said heat exchange with the oxygen product to join the outflowing nitrogen product of said last stage of rectification.

6. A process for conserving liquid oxygen produced by the low temperature rectification of air in stages at successively lower pressures, said liquid oxygen being produced in the last of said rectification stages at a pressure slightly above atmospheric pressure, which process comprises withdrawing a fluid having a substantial nitrogen content from a prior stage of the rectification; effecting heat exchange between said fluid and the cold gaseous nitrogen product of said last stage of rectification to cool said fluid; expanding such withdrawn cooled fluid to substantially the pressure of the last stage of rectification; passing said liquid oxygen in heat-exchanging relation with said expanded fluid to sub-cool the oxygen; and transferring the sub-cooled liquid oxygen to a receiving container wherein it is held under a pressure below that of said last stage of rectification.

7. A process for conserving liquid oxygen produced by the low temperature rectification of air in stages at successively lower pressures, said liquid oxygen being produced in the last of said rectification stages at a pressure slightly above atmospheric pressure, which process comprises withdrawing a fluid having a substantial nitrogen content from a prior stage of the rectification; dividing said fluid into two portions; expanding and passing one of said portions of fluid to the last stage of rectification; expanding and completely vaporizing the other portion of said fluid in heat-exchanging relation with said liquid oxygen product of the last stage of rectification to sub-cool the same; and transferring such sub-cooled liquid oxygen to a receiving container wherein it is held under a relatively low pressure.

8. A process for conserving liquid oxygen according to claim 7 which includes the step of conducting the vapors resulting from said heat exchange of said fluid with the oxygen product to join the nitrogen product of said last stage of rectification.

9. A process for conserving liquid oxygen produced by the low-temperature rectification of air in stages at successively lower pressures, said liquid oxygen being produced in the last of said rectification stages at a pressure slightly above atmospheric pressure, which process comprises withdrawing a fluid having a substantial nitrogen content from a prior stage of the rectification; expanding such withdrawn fluid to at least substantially the pressure of the last of said rectification stages; passing said liquid oxygen in heat-exchanging relation with said expanded fluid to sub-cool the oxygen; transferring the sub-cooled liquid oxygen to a receiving container wherein it is held under a pressure below that of said last stage of rectification; withdrawing vapors from said receiving container from above the liquid therein; subjecting such vapors to heat exchange with another portion of fluid having a relatively high nitrogen content discharged from said rectification stages so as to liquefy said vapors; and transferring the liquid resulting from said liquefaction to said receiving container.

10. Process for conserving liquid oxygen produced by the low temperature rectification of air in two stages at successively lower pressures which process comprises passing said liquid oxygen product into a receiving container insulated from the effects of the surrounding temperatures; withdrawing vapors from said receiving container from above the liquid therein; subjecting such vapors to heat exchange with a body of liquid having a substantial nitrogen content drawn from said rectification so as to vaporize a portion of said body of liquid and liquefy said vapors; and transferring the liquid oxygen so produced to said receiving container.

11. A process for conserving a liquefied gas product resulting from the low-temperature rectification of a gas mixture in stages at different pressures, which process comprises withdrawing a fluid having a substantial content of a lower boiling point component of said gas mixture from a stage of the rectification other than the lowest pressure stage; expanding such withdrawn fluid to at least substantially the pressure of the lowest of said rectification stages; bringing said gas product into heat-exchanging relation with said expanded withdrawn fluid to sub-cool said gas product; and passing said sub-cooled product into a receiving container wherein it is held in the liquid state at a relatively low pressure.

12. A process for conserving oxygen produced by the low-temperature rectification of air in stages at successively lower pressures, said oxygen being produced in the last of said rectification stages at a pressure slightly above atmospheric pressure, which process comprises withdrawing a fluid having a substantial nitrogen content from a prior stage of the rectification; expanding such withdrawn fluid to at least substantially the pressure of the last of said rectification stages; effecting heat exchange between said expanded fluid and said oxygen product to cool the latter to a temperature such that it is entirely liquid and remains in the liquid state when transferred to a receiver at a lower pressure; and transferring said oxygen product to such receiving container for storage therein.

13. Apparatus for conserving liquid oxygen produced by a two-stage air-rectifying apparatus, said liquid oxygen being produced in the stage operating at the lower pressure, comprising means for withdrawing a fluid having a substantial nitrogen content from the higher-pressure stage of said rectifying apparatus; means for expanding such fluid to at least substantially the pressure of the lower-pressure stage of said rectifying apparatus; a heat exchanger arranged to effect heat exchange between said expanded fluid and the oxygen product of the rectifying apparatus to sub-cool the same; a heat-insulated receiving container; and means for transferring said sub-cooled oxygen from said heat exchanger to said receiving container.

14. Apparatus for conserving liquid oxygen according to claim 13 in which said higher-pressure stage comprises a rectifying column having a liquid collecting sump at its lower end, and said fluid withdrawing means is connected to withdraw said fluid from said sump.

15. Apparatus for conserving liquid oxygen according to claim 13 in which said higher-pressure stage comprises a rectifying column having a liquid collecting sump at its lower end, a condenser at its upper end cooled by boiling oxygen, and a shelf for collecting a substantial portion of the condensate produced by said condenser; and in

which said fluid-withdrawing means is connected to withdraw said fluid from said shelf.

16. Apparatus for conserving liquid oxygen according to claim 13 in which said higher-pressure stage comprises a rectifying column having a liquid-collecting sump at its lower end, and in which said apparatus includes a heat-insulated vessel for holding a body of cold liquid; means for conducting portions of liquid from said sump to said vessel; means for withdrawing vapors from said receiving container and passing such vapors in heat-exchanging relation with the body of liquid in said vessel to condense said vapors; and means for transferring liquid produced by condensation of said vapors to said receiving container.

17. System for dispensing liquid oxygen produced by a two-stage air-rectifying apparatus, said liquid oxygen being produced in the stage operating at the lower pressure, said system comprising an elevated heat-insulated storage tank adapted to hold a supply of liquid oxygen; means for sub-cooling said liquid oxygen product of the rectifying apparatus by heat exchange with a colder fluid drawn from said rectifying apparatus; means for transferring such sub-cooled liquid oxygen to said storage tank under a pressure lower than that of said lower-pressure rectification stage; a heat-insulated transport container positioned at a lever lower than that of said storage tank; and conduit means connecting the lower portion of said storage tank with said transport container for transferring liquid by gravity from the storage tank to the transport container to charge the same, whereby substantial flashing of liquid into gas is avoided.

18. Apparatus for conserving liquid oxygen produced in the lower-pressure stage of a two-stage air-rectifying apparatus which comprises means for withdrawing a fluid having a substantial nitrogen content from the higher-pressure rectification stage; means for passing such fluid in heat-exchanging relation with the cold nitrogen product of said low-pressure stage to cool the same; means for expanding such fluid to at least substantially the pressure of the low-pressure stage; a heat exchanger arranged to effect heat exchange between said expanded fluid and the oxygen product of said rectifying apparatus to sub-cool the same; a heat-insulated receiving container; and means for transferring said sub-cooled oxygen from said heat exchanger to said receiving container for storage therein at a relatively low pressure.

19. Apparatus for conserving liquid oxygen produced by the low-pressure stage of a two-stage air-rectifying apparatus which comprises means for withdrawing a fluid having a substantial nitrogen content from the higher-pressure stage of said rectification; means for conducting a portion of such fluid in heat-exchanging relation with the nitrogen product discharged from said low-pressure stage; means for expanding and introducing such cooled portion of fluid into the upper end of said low-pressure stage; means for expanding the remaining portion of said fluid to the pressure of the nitrogen product of said low-pressure stage; a heat exchanger arranged to effect heat exchange between said expanded portion of fluid and the oxygen product of said low-pressure stage to sub-cool the same; a heat-insulated receiving container; means for transferring said sub-cooled oxygen from said heat exchanger to said receiving container; and means for conducting the vapors of said fluid from said heat exchanger to join with the nitrogen product of said low-pressure stage.

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