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VAPOR OXYGEN RECONDENSER

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Fig. 1.

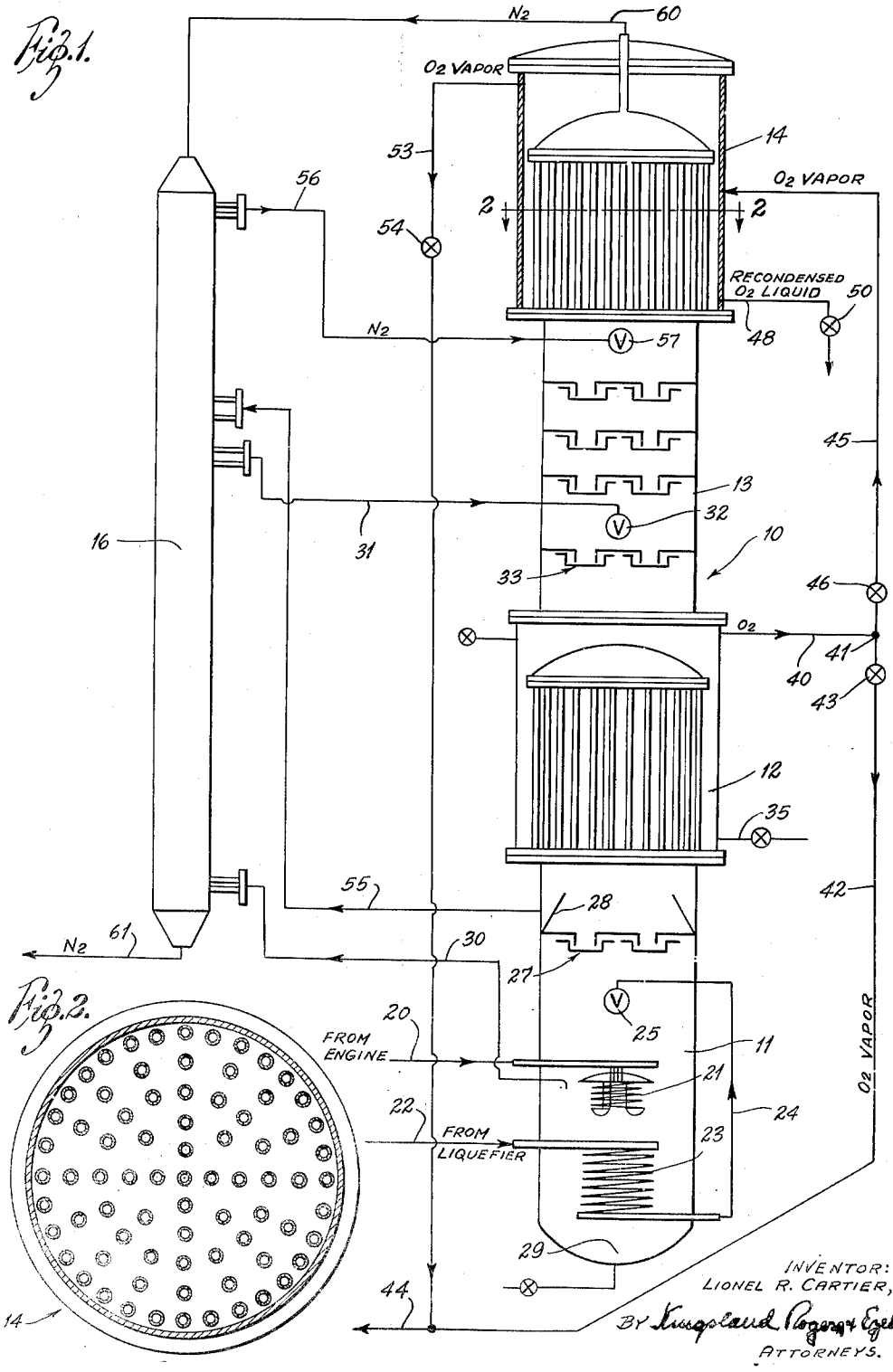


Fig. 2.

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VAPOR OXYGEN RECONDENSER

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3 Claims. (Cl. 62—122)

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The present invention relates to a vapor oxygen recondenser, or to a recondenser for a rectifier system operating comparably to a system for production of oxygen from air. More particularly, it relates to a recondenser for use in connection with oxygen columns of the presently existing type, which recondenser is adapted to take vapor oxygen from the column and recondense the same at least in part, employing as a refrigerating agent vapor nitrogen from another part of the column which is vaporized and expanded in heat transfer relationship to the oxygen, so that the nitrogen absorbs heat from the oxygen and liquefies at least a part of the latter.

It is an object of the invention to provide an oxygen recondenser of this type which may be added to existing columns. A further object of the invention is to provide a recondenser of this type that will operate with minimum heat loss. A specific object is to provide such a recondenser superposed onto the top of a column of known style, whereby to receive cold nitrogen vapor immediately from the upper rectifying chamber, and into which vapor oxygen from said chamber may be conducted for at least partial liquefaction.

In the drawing:

Fig. 1 is a diagrammatic view of the apparatus of the present invention applied to an oxygen column; and

Fig. 2 is a section on the line 2—2 of Fig. 1.

This invention will be described in connection with the production of oxygen from air. It will be understood, however, that its principles and apparatus are equally applicable to the production of other liquid products of systems that are similar to oxygen producing systems, in fractionating, out of a fluid mixture, one gas having one boiling point from other gas having a different boiling point.

In the drawing, there is a column, generally indicated at **10**. This column has a lower separating chamber **11**, above which is a lower condenser, generally indicated at **12**. Above the lower condenser **12**, there is an upper separating chamber **13**. Above this, in the present invention, there is mounted an additional condenser **14**, that comprises a heat exchanger having separate passes in separated, heat-exchange relationship to each other.

Associated with the column in the present explanation is a sub-cooler, generally designated at **16**. This sub-cooler improves the efficiency of the system, but is not essential to it.

The column, in the manufacture of oxygen, is conventionally associated with sources of air,

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under pressure and usually considerably precooled. In a typical system, there will be an expansion engine and a liquefier, from both of which air is delivered to the lower crude oxygen chamber **11**. An inlet line **20** is illustrated for delivering air from an expansion engine into a coil **21** within the chamber **11**. From this coil, the air is delivered into the chamber **11**. This air from the engine, in the supply line **20**, may be at 80 p. s. i. and —154° C. as it enters the upper coil **21**. Such values are typical of known systems.

Additionally, there is an inlet line **22** from the liquefier which delivers air under pressure to a coil **23** within the chamber **11**. From the other end of this coil, this air is carried by a pipe **24** to a first expansion valve **25**, at which point it is expanded and delivered to the chamber **11**. Typically, the air in the pipe **22** may be at 600 p. s. i. and —130° C. As it passes through the coil **23**, in heat transfer relation with the interior of the chamber **11**, it is cooled to about —177° C. At the expansion valve **25**, it is reduced in pressure to the pressure of the chamber **11**, suggested to be 80 p. s. i., whereupon a portion of the liquefied air flashes into vapor, reducing the temperature of the remainder to or toward the boiling point of the air at the pressure within the chamber **11**.

Conventionally, the chamber **11** above the coils **21** and **23** has liquid receiving trays such as illustrated at **27**. Above these is a liquid shelf **28** below the condenser **12** and adapted to catch a part of the liquid therefrom.

As the air expands from the valve **25**, lowering the temperature of at least part of it, a partial separation occurs, in which a mixture of nitrogen and oxygen rises as a gas, and a mixture of oxygen and nitrogen as a liquid descends onto and through the trays. Vapor from the upper coil **21** rises to bubble through the trays, and is itself cooled by the descending liquid to a temperature at which separation occurs. There is thus produced in a sump **29** at the bottom of the chamber **11** a liquid oxygen-nitrogen mixture, called crude oxygen, and containing in the neighborhood of 50% oxygen. It is generally designated as a liquid rich in oxygen. Its temperature may be about —188° C.

As nitrogen has a lower boiling point than oxygen, it will remain at the temperatures indicated, to a large extent a vapor, which rises into the condenser **12**. Here it is in heat transfer relation with liquid oxygen of the upper column, and is cooled and partly liquefied, this liquid oxygen in the upper column being at a lower pres-

sure. The liquid separated in the condenser 12, in its lower pass, descends, partly mixing with that on the trays, and acting as a reflux liquid. It partly collects on the shelf 28. The liquid on the shelf is largely nitrogen, and is generally designated as a liquid rich in nitrogen owing to the relatively greater percentage of nitrogen in it than in the liquid in the sump 29.

Liquid from the sump 29, which may be at 80 p. s. i. and —188° C., is withdrawn through a pipe 30, connected to the sub-cooler 16. From the sub-cooler 16, the crude oxygen, at a somewhat lower temperature, passes out in a line 31 leading to an expansion valve 32 that discharges into the upper chamber 13. At this point, it expands and cools. If the upper chamber 13 is at a typical 6 p. s. i., the fluid from the expansion valve 32 may reduce in temperature to —191° C., or lower, but above the boiling point of nitrogen and above the boiling point of the liquid rich in nitrogen, there being enough flashing of liquid into gas to produce such temperature reduction. As a result, a further separation takes place, the oxygen liquefying and descending over trays 33 in the chamber 13, and vapor, largely nitrogen, rising. The liquid oxygen in the condenser 12 acts around the gases that have ascended to the inside of the tubes of the condenser 12 from the lower chamber 11 so as to reduce the temperature of such gases and to liquefy them in whole or in part.

In addition to the foregoing, liquid rich in nitrogen from the shelf 28 in the lower chamber 11 is expanded into the upper chamber 13. Desirably, but not necessarily, it is passed through the sub-cooler 16 before being expanded. To accomplish the foregoing, a pipe 55 is connected into the lower chamber to conduct this liquid from the chamber 11. This pipe leads into the cooler 16. A pipe 56 leads from the cooler to an expansion valve 57, that discharges into the upper part of the chamber 13. As this liquid is largely nitrogen, it has a low boiling point, and its expansion to 6 p. s. i. will cause it to lower in temperature toward or to the boiling point of nitrogen at such pressure. For example, this nitrogen will approach —194° C. in the upper part of the chamber 13. It will liquefy oxygen vapor in such part, and cause the oxygen thus to separate out and descend through the trays.

The liquid oxygen in highly purified state decends into the condenser 12 around the tubes. It may be at the boiling point of oxygen for the pressure existing in the condenser, such as —182° C. It may be drawn off through the valved pipe 35. Vapor oxygen rising through the trays is liquefied by contact with the cold oxygen liquid and with the cold nitrogen produced at the expansion valve 57.

Above the liquid oxygen in the condenser, there is vapor oxygen. Such vapor as remains unliquefied may be drawn off and used or stored as vapor oxygen. However, for many reasons, it is desirable to reduce as much vapor oxygen to liquid as is possible.

The present invention increases the amount of liquid oxygen produced, by recondensing a certain portion of the vapor oxygen. Apparatus involved in this will now be described.

A pipe 40, constituting the vapor oxygen outlet from the condenser 12, leads into a T 41 from which a pipe 42, valved at 43, leads into a vapor discharge line 44. Also, from the T 41, a pipe 45, valved at 46, leads into one pass of an upper chamber of a recondenser 14. From this recondenser, a vapor outlet 53, valved at 54, leads into the vapor discharge line 44.

The recondenser 14 has another pass that receives the very cold nitrogen rising from the chamber 11, which transfers heat from the oxygen vapor, and then discharges through a pipe 60. From this pipe, it may flow through one pass of the unit 16, and thence into a nitrogen discharge line 61, that may lead, if desired, into other heat exchangers or apparatus.

When the product from the column is required to be 100% vapor, the valves 46 and 54 are closed. All vapor then flows past the valve 43, by way of the pipe 42 to the discharge line 44 for suitable disposition at point of use or storage.

To recondense the vapor oxygen, the valve 43 is closed and the valves 46 and 54 are opened, forcing all of the vapor oxygen from the line 40 through the line 45 into one pass of the upper chamber of the recondenser 14. Therein a portion of the vapor oxygen is liquefied by heat exchange with the cold nitrogen rising through the other pass of the recondenser chamber. The remaining uncondensed oxygen vapor passes out the line 53, past the valve 54, and into the vapor oxygen discharge line 44.

As this nitrogen vapor through the recondenser 14 is below the boiling temperature of oxygen, and has had little opportunity to become warmed by extraneous heat, it absorbs heat from the oxygen vapor, and causes a substantial part thereof to liquefy and collect in the bottom of the upper condenser 14. This may be drawn off by the pipe 48, valved at 50.

The foregoing system takes vapor oxygen at a point where it is substantially free of nitrogen. The pipe 40 draws off from the top of the condenser, near the liquid level of the oxygen in the condenser, and at a level, with respect to the chamber 13, below that at which nitrogen in substantial ratio is found. This vapor is then transferred to the top of the column, into heat transfer relationship with the expanded vapor nitrogen at its coldest range of temperatures, and where the nitrogen has had minimum opportunity to gain heat beyond that absorbed from the vapors and liquid in the chamber 13.

The present arrangement saves space, and is readily added to existing columns. It has been found to increase the liquid oxygen production substantially, by liquefying as much as 30–35% of the vapor oxygen.

What is claimed is:

1. An apparatus for producing liquid oxygen, including a column having an upper chamber in the bottom of which liquid oxygen is produced with vapor oxygen immediately thereabove, and in the top of which vapor nitrogen is produced at temperatures below the boiling point of oxygen, an oxygen vapor draw-off connected into said chamber immediately above the liquid level, an oxygen discharge outlet connected to the draw-off, a heat exchanger superposed on the chamber, having a first pass directly open to the chamber to receive the cold nitrogen vapor, and having a nitrogen outlet at its other end, and having a second pass in heat transfer relationship to the first pass, a connection between the second pass and the vapor oxygen space above the liquid in the chamber, an opposite connection from the second pass to the oxygen discharge outlet, means to regulate the amounts of oxygen vapor sent directly to the oxygen discharge outlet and to the second pass, and means to withdraw liquid oxygen from the heat exchanger.

2. In an oxygen column, an upper chamber having an inlet for reception of an expanding liquid rich in oxygen and another inlet for reception of an expanding liquid rich in nitrogen, a collector for liquid oxygen at the bottom of the chamber, an outlet adjacent to but above the bottom of the chamber for withdrawal of pure vapor oxygen immediately above the liquid oxygen, a heat-exchange device at the top of the chamber above the nitrogen inlet, the heat exchanger having two passes in heat-exchange relationship, one being a nitrogen gas pass directly open to the chamber and forming a continuation thereof, a nitrogen outlet above the heat exchanger, to cause nitrogen to rise in the upper chamber, pass through the nitrogen pass of the heat exchanger, and act in heat transfer relationship to the other pass, and means connecting the vapor oxygen outlet into the other pass, a liquid oxygen outlet from said oxygen pass of the heat exchanger, and a vapor oxygen outlet from said pass, whereby said vapor oxygen may be at least partially liquefied by heat transfer into the vapor nitrogen as the latter rises directly from the upper chamber.

3. In an air rectification column for liquefying a first gas out of air containing at least one other gas herein designated a second gas, the first gas having a higher boiling point than the second gas: an upper chamber having an inlet for reception of an expanding liquid rich in the first gas and another inlet for reception of an expanding liquid rich in the second gas, a collector for liquefied first gas at the bottom of the chamber,

an outlet adjacent to but above the bottom of the chamber for withdrawal of pure first gas immediately above the liquefied first gas, a heat exchange device at the top of the chamber above the second gas inlet, the heat exchanger having two passes in heat exchange relationship, one being a second gas pass directly open to the chamber and forming a continuation thereof, a second gas outlet above the heat exchanger to cause the second gas to rise in the upper chamber, pass through the second gas pass of the heat exchanger and act in heat transfer relationship to the other pass, and means connecting the first gas vapor outlet into the other pass, a liquid first gas outlet from said first gas pass of the heat exchanger, and a vapor first gas outlet from said pass, whereby said first gas may be at least partially liquefied by heat transfer into the first gas as the latter rises directly from the upper chamber.

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