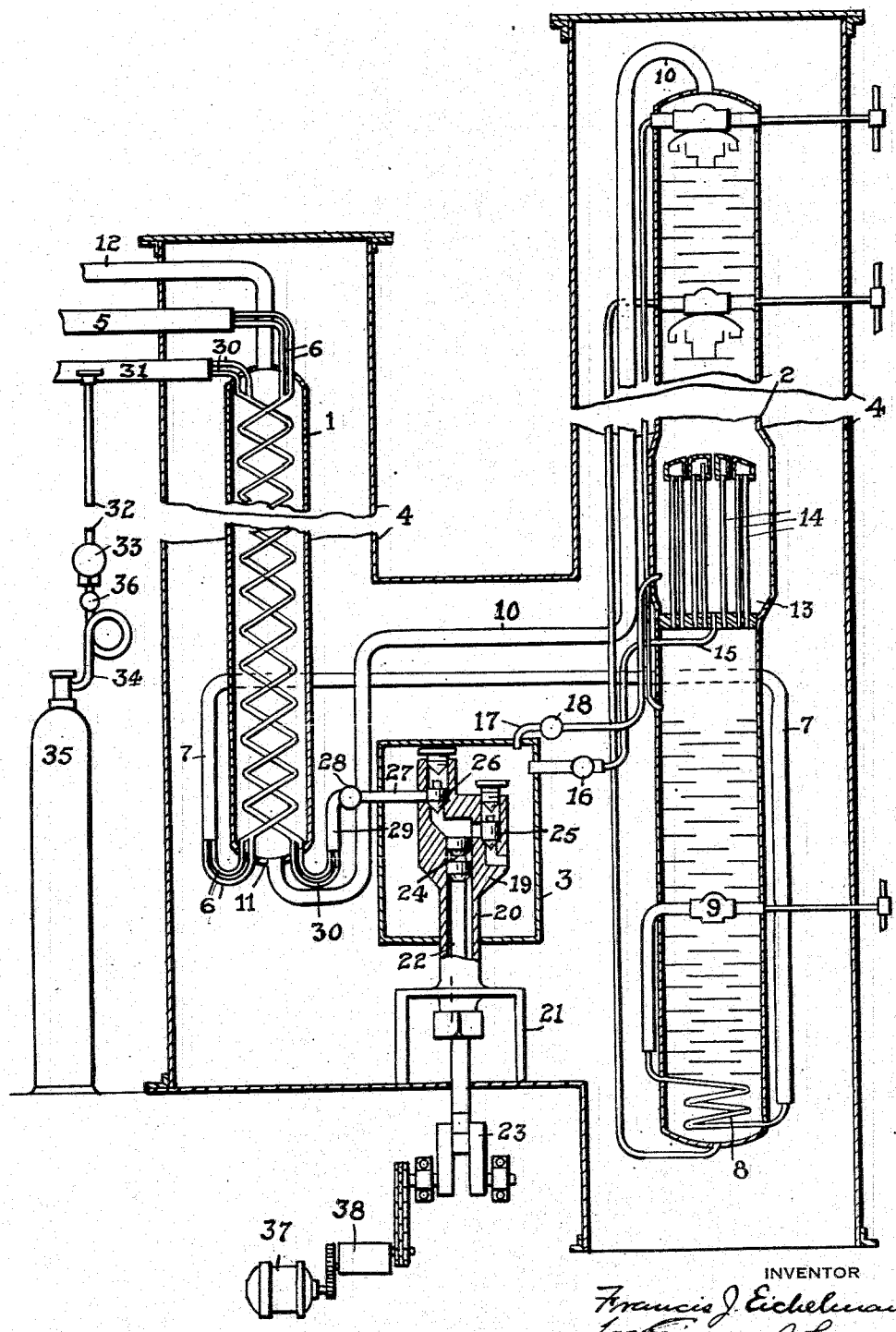
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APPARATUS FOR PRODUCING OXYGEN FROM LIQUID AIR

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APPARATUS FOR PRODUCING OXYGEN FROM LIQUID AIR

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In the practice of this art as now in general use, the air which has been previously freed from moisture and carbon dioxide, is compressed, cooled and delivered through a heat-exchanger, wherein it is further cooled by the passage of the oxygen and nitrogen gases in close proximity thereto, to the rectification column wherein the air is first liquefied and then by a process of distillation the liquefied air is separated into its prime constituents, oxygen and nitrogen, and these gases are caused to travel to the bottom of the heat-exchanger, the oxygen gas reaching the heat-exchanger at a pressure slightly above atmospheric pressure. The oxygen passes from the upper end of the heat-exchanger at a pressure sufficient to lift the water-sealed gas-holder.

As much greater pressures are required for the storage or in the use of oxygen gas, such for instance as in a cylinder where a pressure of approximately two thousand pounds at 70° Fahr. is desirable, compressors are employed in the present to produce the desired pressures.

However certain difficulties are encountered in this practice. Thus such compressors are expensive and their operation requires the expenditures of considerable power. Again the problem of lubrication of the moving parts is a serious one. The use of hydrocarbon lubricants is impossible because of the action of oxygen on hydrocarbon especially in the presence of the pressure, temperature and friction conditions encountered in compression of this nature.

Water is frequently used as a lubricant in such compressors but the result is that the compressed oxygen delivered by the compressors is more or less saturated with water vapor and its usefulness for many important purposes is seriously impaired. Again such lubrication is imperfect and excess wear occurs.

In my present invention I avoid the above mentioned difficulties attendant upon the use of compressors by taking off the liquid oxygen from the low pressure side of the rectification column and supplying it by forced feed to the bottom or intake end of the heat-exchanger, thus maintaining a controlled and regulable supply of the oxygen to the heat-exchanger tubes.

As a result the supply of liquid oxygen to the oxygen tubes of the heat-exchanger is maintained regardless of the pressure in said tubes, which pressure will vary with the pressure at the point of delivery of the oxygen gas, such for instance as a cylinder or other high pressure receiver.

On the contrary under the present practice the pressure in the oxygen tubes of the heat-exchanger must remain below those in the low pressure side of the rectification column, for otherwise the operation of the column would be interfered with and eventually halted.

I thus avoid the necessity of employing compressors to compress the oxygen to the desired pressure for storage or use after it has left the heat-exchanger.

For the convenient accomplishment of my improved process I have invented the hereinafter described apparatus which is especially designed and adapted for that purpose.

In the accompanying drawing, wherein I have illustrated a practical embodiment of the principles of my invention, I have illustrated in broken vertical section such apparatus comprising a heat-exchanger, a rectification column, and a liquid oxygen pump operatively interposed between the same, all of said elements being enclosed in an insulated outer enclosure.

Referring to the drawing, 1 represents the heat-exchanger, 2 the rectification column, 3 the moisture-tight casing or tank of the liquid oxygen pump, and 4 the outer enclosure. The purified, dried, compressed and preliminarily cooled air travels by means of the pipe 5 to the upper end of the bank of helical tubes 6 which extend downwardly within the tubular casing of the heat-exchanger 1. The lower ends of the tubes 6 connect to the pipe 7 which is covered with suitable heat-insulation and whose other end is connected to the boiling coil 8 which is immersed in the bath of liquid air in the bottom of the high pressure side of the rectification column 2. The other end of the boiling coil 8 is connected to the expansion valve 9 in the high pressure side of the column 2.

The nitrogen gas is led from the top of the low pressure side of the column 2 through a pipe 10 which connects at 11 with the bottom of the casing of the heat-exchanger 1. A pipe 12 leads from the top of said casing to carry off the nitrogen gas.

The specific internal construction of the rectification column is not the subject matter of the present invention, and the structure above described is well known in the present practice of the art.

The liquid oxygen collects in the bottom 13 of the low pressure side of the column 2 surrounding the condenser tubes 14. From said bottom a descending pipe 15 leads to the upper portion of the pump casing 3, said pipe being provided with a valve 16. Thus the liquid oxygen flows into

said casing. To relieve the casing 3 from such oxygen gas which may collect in the upper part of said casing an escape pipe 17 leads upwardly from the top of said casing to the low pressure side of the column 2 above the bottom 13, said pipe being provided with a valve 18. Thus any gas which may collect in the top of the casing 3 may be relieved, enabling the casing to be kept at all times substantially full of liquid oxygen.

19 is the pump barrel mounted within the casing 3 and immersed in liquid oxygen. Said barrel is provided with a depending tubular neck 20 which extends through the bottom of the casing with an air-tight joint. The pump is supported by the frame 21. 22 is a piston rod working in said neck and driven as by the crank shaft 23 connected to its lower end. The upper end of the piston rod is provided with a piston 24.

The pump barrel is provided with an inwardly opening inlet valve 25 communicating with the interior of the casing 3 and an outwardly opening discharge valve 26 which is connected by a pipe 27, having a valve 28, to a pipe 29 which connects at the bottom of the heat-exchanger 1 with the bank of helical tubes 30 which extend upwardly through the heat-exchanger and are connected at the top of the latter with an insulated pipe 31 which in turn is connected by a pipe 32 with the header 33 from which lead the branch pipes 34 which are detachably coupled to the cylinders indicated at 35. Each of the branch pipes 34 is provided with a valve 36.

When the device has been put into operation the supply of substantially pure liquid oxygen in the bottom 13 of the low pressure side of the column 2 is substantially constant, and thus with the valve 16 open the casing 3 is kept full of liquid oxygen, any gas which may collect being relieved through the pipe 17.

The operation of the pump maintains a constant supply of liquid oxygen to the lower ends of the helical oxygen tubes 30, and the action of the heat-exchanger, comprising the exchange of heat from the compressed air tubes to the oxygen tubes 30, completely gasifies the oxygen during its ascent of said tubes 30, thus supplying oxygen gas through the pipes 31 and 32 and header 33 to the branch pipes 34 which supply the gas to the cylinder 35.

I encounter no difficulty in the operation of the liquid oxygen pump as its valves and the piston are sufficiently lubricated by the liquid oxygen.

To enable me to vary the speed of the pump, for the purpose of regulating the supply of liquid oxygen to the heat-exchanger, I may drive the crank shaft 23 by means of a variable speed motor 37 through a speed reducer 38.

By varying the speed of the pump or other forced feed device I am able to maintain the operation of the rectification column at maximum efficiency as I am thus enabled to withdraw the liquid oxygen from the column at the proper rate to balance its separation. If the liquid oxygen be withdrawn from the column in too small quantities, the oxygen not withdrawn tends to pass off with the nitrogen, while a withdrawal of the liquid oxygen at an excess rate will tend to decrease the purity of the oxygen withdrawn.

I claim:—

1. In apparatus for producing and delivering oxygen gas under pressures substantially in excess of those under which the oxygen is separated, the combination of a heat-exchanger by which compressed air is cooled by travelling in proximity to the out-going products of the apparatus, a rectification column in which the air is liquefied and the oxygen and nitrogen are separated, a chamber into which the liquid oxygen flows from the column, and a forced feed device submerged in the body of liquid oxygen within said chamber having its inlet connected to the interior of the chamber and its discharge connected to the oxygen tube of the heat-exchanger whereby liquid oxygen is supplied to the heat-exchanger and is vaporized therein.

2. In apparatus for producing and delivering oxygen gas under pressures substantially in excess of those under which the oxygen is separated, the combination of a heat-exchanger by which compressed air is cooled by travelling in proximity to the out-going products of the apparatus, a rectification column in which the air is liquefied and the oxygen and nitrogen are separated, a chamber into which the liquid oxygen flows from the column, a forced feed device submerged in the body of liquid oxygen within said chamber having its inlet connected to the interior of the chamber and its discharge connected to the oxygen tube of the heat-exchanger whereby liquid oxygen is supplied to the heat-exchanger and is vaporized therein, and a high-pressure receiver directly connected to the oxygen tube of the heat-exchanger and into which oxygen gas passes under the pressure of vaporization.

3. In apparatus for producing and delivering oxygen gas under pressures substantially in excess of those under which the oxygen is separated, the combination of a heat-exchanger by which compressed air is cooled by travelling in proximity to the out-going products of the apparatus, a rectification column in which the air is liquefied and the oxygen and nitrogen are separated, a chamber into which the liquid oxygen flows from the column, a forced feed device within said chamber having its inlet connected to the interior of the chamber and its discharge connected to the oxygen tube of the heat-exchanger whereby liquid oxygen is supplied to the heat-exchanger and is vaporized therein, and means for returning any oxygen gas in said chamber to the column.

4. In apparatus for producing and delivering oxygen gas under pressures substantially in excess of those under which the oxygen is separated, the combination of a heat-exchanger by which compressed air is cooled by travelling in proximity to the out-going products of the apparatus, a rectification column in which the air is liquefied and the oxygen and nitrogen are separated, a gravity-filled chamber into which the liquid oxygen flows from the column, and a forced feed device submerged in the body of liquid oxygen within said chamber having its inlet connected to the interior of the chamber and its discharge connected to the oxygen tube of the heat-exchanger whereby liquid oxygen is supplied to the heat-exchanger and is vaporized therein.

5. In apparatus for producing and delivering oxygen gas under pressures substantially in excess of those under which the oxygen is separated, the combination of a heat-exchanger by which compressed air is cooled by travelling in proximity to the out-going products of the apparatus, a rectification column in which the air is liquefied and the oxygen and nitrogen are separated, a gravity-filled chamber into which the liquid oxygen flows from the column, a forced feed device within said chamber having its inlet connected to the interior of the chamber and its discharge connected

to the oxygen tube of the heat-exchanger whereby liquid oxygen is supplied to the heat-exchanger and is vaporized therein, and means for returning any oxygen gas in said chamber to the column.

6. In apparatus for producing and delivering oxygen gas under pressures substantially in excess of those under which the oxygen is separated, the combination of a heat-exchanger by which compressed air is cooled by travelling in proximity to the out-going products of the apparatus, a rectification column in which the air is liquefied and the oxygen and nitrogen are separated, a low level chamber into which liquid oxygen flows by gravity from the column, a passage for the escape of gasified oxygen from the chamber to the column, and a force-feed device having its intake connected to the chamber and its discharge connected to the oxygen tube of the heat-exchanger whereby liquid oxygen is supplied to the heat-exchanger to be gasified therein.

7. In apparatus for producing and delivering oxygen gas under pressures substantially in excess of those under which the oxygen is separated, the combination of a heat-exchanger by which compressed air is cooled by travelling in proximity to the out-going products of the apparatus, a rectification column in which the air is liquefied and the oxygen and nitrogen are separated, a low level chamber into which liquid oxygen flows by gravity from the column, a passage for the escape of gasified oxygen from the chamber to the column, a force-feed device having its intake connected to the chamber and its discharge connected to the oxygen tube of the heat-exchanger whereby liquid oxygen is supplied to the heat-exchanger to be gasified therein, and means for varying the discharge of the force-feed device whereby to maintain the rate at which the liquid oxygen is efficiently produced by the column.

8. In apparatus for producing and delivering oxygen gas under pressures substantially in excess of those under which the oxygen is separated, the combination of a heat-exchanger by which compressed air is cooled by travelling in proximity to the out-going products of the apparatus, a rectification column in which the air is liquefied and the oxygen and nitrogen are separated, a low level chamber into which liquid oxygen flows by gravity from the column, a valved passage for the escape of gasified oxygen from the chamber to the column, and a force-feed device having its intake connected to the chamber and its discharge connected to the oxygen tube of the heat-exchanger whereby liquid oxygen is supplied to the heat-exchanger to be gasified therein.

9. In apparatus for producing and delivering oxygen gas under pressures substantially in excess of those under which the oxygen is separated, the combination of a heat-exchanger by which compressed air is cooled by travelling in proximity to the out-going products of the apparatus, a rectification column in which the air is liquefied and the oxygen and nitrogen are separated, a low level chamber into which liquid oxygen flows by gravity from the column, a valved passage for the escape of gasified oxygen from the chamber to the column, a force-feed device having its intake connected to the chamber and its discharge connected to the oxygen tube of the heat-exchanger whereby liquid oxygen is supplied to the heat-exchanger to be gasified therein, and means for varying the discharge of the force-feed device whereby to maintain the rate at which the liquid oxygen is efficiently produced by the column.

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