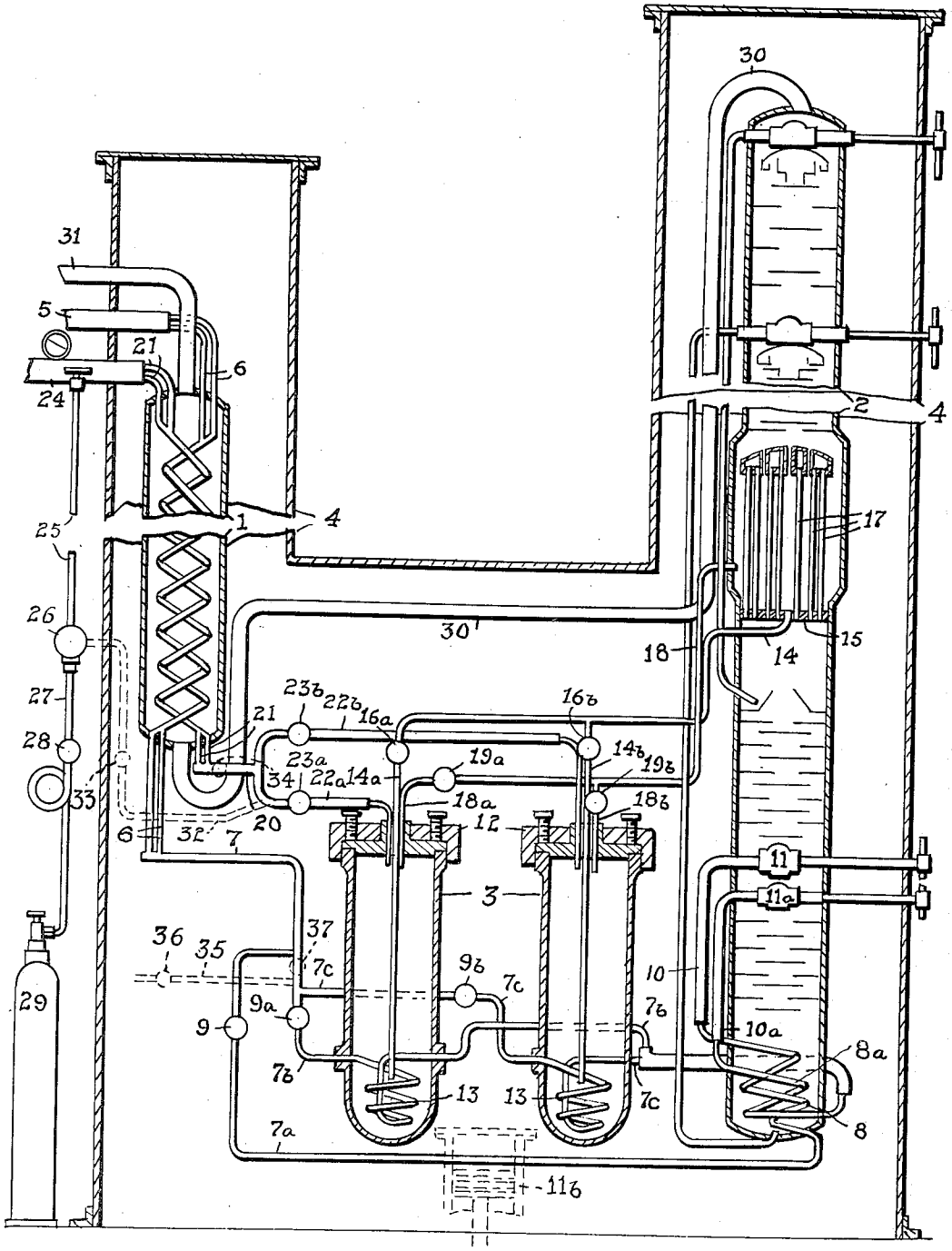
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APPARATUS FOR PRODUCING OXYGEN FROM LIQUID AIR

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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, preliminarily cooled and delivered through a heat-exchanger, wherein it is 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 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 practice to produce the desired pressures.

However certain difficulties are encountered in this practice. Thus such compressors are expensive and their operation requires the expenditure 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 hydrocarbons, especially in the presence of pressure, temperature and friction conditions encountered in compression of this nature.

Water is frequently used as the lubricant with the result that the compressed oxygen delivered by the compressors is more or less saturated with water vapor and thus its usefulness for many important purposes is seriously impaired, and again, the lubrication is imperfect and excess wear results.

In my present invention I avoid the above mentioned difficulties attendant upon the use of compressors, by taking off the oxygen in a liquid state from the low pressure side of the rectification column and vaporizing it before admitting it to the heat-exchanger or a pressure container, and by the regulation and control of the rate of vaporization maintaining at the oxygen outlet the desired delivery pressures.

I accomplish this vaporization by means of one or more, preferably a plurality of vaporizers operatively interposed between the rectification column and the heat-exchanger.

These vaporizers are containers or tanks which are filled with liquid oxygen from the low pressure side of the column and the vaporization of the liquid in the tanks is accomplished by means of evaporating coils immersed in the contents of the tanks and through which controlled quantities of the compressed air are caused to pass on their travel to the rectification column.

By providing a plurality of such vaporizing tanks, the contents of one or more of the tanks may be vaporized and supplied to the oxygen tubes of the heat-exchanger, or to a pressure container, while the remaining tank or tanks are being refilled with liquid oxygen from the rectification column.

To facilitate the filling of the tanks with liquid oxygen, means are provided for venting any oxygen gas which may collect in the tank back into the low pressure side of the column.

To provide for adequate control and regulation of the operation of the rectification column and also of the vaporization of the liquid oxygen in the individual vaporizers, so that both a proper supply of liquid oxygen may be maintained in the column and also the vaporized oxygen may be supplied to the heat-exchanger or direct to the pressure container in proper column and at the desired pressure, I provide the high pressure side of the column with separate boiling coils, one for direct connection with the air tubes of the heat-exchanger, and one or more connected to said pipe through the evaporator coils, together with suitable control valves. Thus I may accurately regulate and control the relative actions of the column and the vaporizers.

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 show in vertical section a heat-exchanger, a rectification column and a pair of vaporizers operatively interposed between the former, and all inclosed in an insulated outer closure.

Referring to the drawing, 1 represents the heat-exchanger, 2 the rectification column, 3 the vaporizers, and 4 the outer enclosure.

The purified, dried and preliminarily cooled air is supplied under pressure through pipe 5 to the upper end of the bank of helical tubes 6 which extend downwardly through the casing of the heat-exchanger 1.

The lower ends of the tubes 6 are connected to a pipe 7 which has three branches indicated at 7a, 7b and 7c. The branch 7a is connected

directly to one end of the boiling coil 8 immersed in the bath of liquid air contained in the bottom of the high-pressure side of the column 2 and said branch 7a is provided with a valve 9.

The other end of the coil 8 is connected by a rising tube 10 with an expansion valve 11 located in the high pressure side of the column.

If desired the expansion valve 11 may be omitted and an expansion engine indicated in dotted lines 11b may be interposed in the pipe 7a, as is sometimes done in the present practice.

The structure of the column is of a well known type and therefore I shall describe the same only in a general way with special reference to my improvements.

The vaporizers 3 are preferably vertically disposed tanks positioned below the level of the low pressure side of the column 2. Each of the tanks has a detachable gas-tight head 12, and in the bottom of each of the tanks is located an evaporating coil 13. The evaporating coil of one tank, the left hand one in the drawing, is interposed in the branch pipe 7b, while the coil of the other tank is interposed in the branch pipe 7c. These branch pipes 7b and 7c are provided with individual valves, 9a and 9b, interposed between the coils and the main pipe 7.

The other ends of the branches 7b and 7c are connected to one end of a second boiling coil 8a located in the bottom of the high-pressure side of the column 2, and the other end of the coil 8a is connected by a rising pipe 10a with a second expansion valve 11a adjacent to the valve 11.

It is evident that the compressed air may be simultaneously or selectively supplied to the boiling coils 8 and 8a and that supplied to the coil 8a may be caused to travel through the evaporating coil of either tank.

A tube 14 leads downwardly from the bottom 15 of the low pressure side of the column 2 and has branches 14a and 14b, provided respectively with valves 16a and 16b, which branches extend down through the heads 12 of the tanks to a point adjacent to the bottoms of the tanks.

By opening the proper valve 16a or 16b, the corresponding tank may be filled with liquid oxygen from the accumulation thereof in the bottom of the low pressure side of the column around the condenser tubes 17.

To facilitate the filling of the tanks I relieve back pressure therein by providing a vent pipe 18 which connects to the low pressure side of the column 2 above the bottom 15, the lower end of the pipe having two branches 18a and 18b which extend through the heads 12 of the tanks. The branches 18a and 18b are each provided with a valve shown at 19a and 19b.

20 is a tube connected at one end to the lower end of the oxygen tubes 21 of the heat-exchanger 1, said pipe having branches 22a and 22b which are provided with valves 23a and 23b, and which extend through the heads 12 of the vaporizing tanks.

The upper ends of the oxygen tubes 21 are connected to a heat-insulated pipe 24 which is in turn connected by a pipe 25 to a header 26 provided with branch pipes 27, having valves 28, which pipes 27 are detachably coupled to the cylinders indicated at 29.

30 represents the nitrogen pipe which leads from the column 2 to the lower end of the casing of the heat-exchanger 1. A nitrogen lead-off pipe 31 connects to the top of the casing of the heat-exchanger.

In operating my apparatus, the liquid oxygen contents of one of the vaporizers is being vaporized and driven through the heat-exchanger while the other vaporizer is being refilled with liquid oxygen, and thus a tank is alternately filled and its contents vaporized.

Assuming that the left hand vaporizer in the drawing has been filled with liquid oxygen and the right hand vaporizer has had its liquid oxygen contents evaporated, the valves 16a and 19a are closed and the valves 9a and 23a are opened, thus causing a portion of the compressed air from the heat-exchanger to pass through the evaporating coil 13 in the bottom of the left hand vaporizer, and thereby starting the vaporization of the contents of the left hand vaporizer with the result that oxygen gas thus formed passes through the branch 22a and pipe 20 to the oxygen tubes 21 of the heat-exchanger and ascending said tubes passing out through pipes 24 and 25, header 26 and branch pipes 27 to the cylinder bank.

Turning now to the right hand vaporizer, the valve 9b is closed cutting off the air from the evaporating coil, the valve 23b is closed to cut the vaporizer from the oxygen tubes of the heat-exchanger, the valve 16b is opened to admit liquid oxygen to the tank from the low pressure side of the column 2 and the valve 19b is opened to vent the oxygen gas above the liquid accumulating in the vaporizer.

When the contents of the left hand vaporizer has been vaporized and the right hand vaporizer has been filled, the arrangement of the valves is reversed, and the contents of the right hand vaporizer is vaporized into the oxygen tubes of the heat-exchanger while the left hand vaporizer is being refilled.

It is evident that the heat-exchange incident to vaporizing the contents of a tank will lower the temperature of the compressed air passing through the evaporating coil and thus there is a supplementary cooling of such air in addition to that incident to the cooling in the heat-exchanger 1.

The volume and pressure at which the oxygen gas is delivered to the cylinder bank is readily controlled by the regulation of the intensity of the vaporization of the oxygen in the vaporizing tanks, and this intensity may be regulated by the proper adjustment of the valves 11 and 11a which control and proportion the volume of the air passing through the evaporating coils.

By providing two boiling coils 8 and 8a in the high pressure side of the column 2 and connecting one directly with the air tubes of the heat-exchanger while the other is connected through either one of the evaporating coils 13, I am able to regulate the vaporization of the liquid contents of the vaporizers without affecting the efficient operation of the column in the production and maintenance of a sufficient supply of liquid oxygen, since the valves 11 and 11a may be adjusted to maintain the proper ebullition in the column without impairing the operation of the vaporizer.

I am thus enabled to deliver the oxygen gas at the desired pressures to the cylinders or other high-pressure receivers without employing mechanical compression or mechanical movement of any character.

Again, I may connect the vaporizer or vapor-

izers directly to the pressure container or containers, such as the cylinder 29, and thus admit the oxygen gas to the containers without passing it through the heat-exchanger.

This is advisable in connection with some types of restification columns wherein a very uniform condition of pressure and temperature is required.

I thus avoid a variation in the cooling of the compressed air in the heat-exchanger caused by variation in pressure in the oxygen tubes of the heat-exchanger.

I have illustrated in dotted lines at 32 such a direct connection between the oxygen pipe 20 and the header 26. A valve 33 in the pipe 32 and a valve 34 in the pipe 20, adjacent to its connection to the oxygen tubes 21, being provided to direct the flow of oxygen gas either through the heat-exchanger or directly to the pressure containers, as may be proper.

Again, the compressed air, or a portion thereof, which is to be passed through the evaporator coils of the evaporators, may be supplied from another source than through the heat-exchanger 1.

Thus I have indicated in dotted lines at 35 a compressed air supply pipe connected to the branches 7*b* and 7*c*, a valve 36 in the pipe 35 and a valve 37 between the pipe 7 and the branches 7*b* and 7*c* being provided so that the coils 13 may be connected up with either source.

I claim:—

1. In apparatus for producing and delivering oxygen gas under pressure, the combination of a rectification column in which air is liquefied and separated into oxygen and nitrogen, a vaporizer into which the oxygen in a liquid state is led from the column, a valved passage connecting the upper end of the vaporizer to the low pressure side of the rectification column for returning any vaporized oxygen to the column while the vaporizer is being filled with liquid oxygen, and controlled evaporating means in said vaporizer whereby the oxygen in a gaseous state may be delivered at a desired pressure.

2. In apparatus for producing an delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and wherein the air is liquefied and separated into nitrogen and oxygen, a container into which the liquid oxygen flows by gravity from the column, a valved passage connecting the upper end of the container to the low pressure side of the rectification column for returning any vaporized oxygen to the column while the container is being filled with liquid oxygen, and an evaporating coil in said container and through which coil compressed air passes to the column.

3. In apparatus for producing an delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and wherein air is liquefied and separated into nitrogen and oxygen, a container into which the liquid oxygen flows by gravity from the column, a valved passage connecting the upper end of the container to the low pressure side of the rectification column for returning any vaporized oxygen to the column while the container is being filled with liquid oxygen, an evaporating coil in said container and through which coil compressed air passes to the column, and a heat-exchanger through which the oxygen gas passes from the container in heat-exchange relation with the air supply.

4. In apparatus for producing and delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and wherein the air is liquefied and separated into nitrogen and oxygen, a heat-exchanger wherein the air supply is cooled by travelling in proximity of the products, a vaporizing container to which the oxygen in a liquid state is led from the column a valved passage connecting the upper end of the container to the low pressure side of the rectification column for returning any vaporized oxygen to the column while the container is being filled with liquid oxygen, and a branched pipe leading air from the heat-exchanger to the column, and an evaporator coil in the container interposed in one of said branches.

5. In apparatus for producing and delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and wherein the air is liquefied and separated into nitrogen and oxygen, a heat-exchanger wherein the air supply is cooled by travelling in proximity of the products, a vaporizing container to which the oxygen in a liquid state is led from the column, a valved passage connecting the upper end of the container to the low pressure side of the rectification column for returning any vaporized oxygen to the column while the container is being filled with liquid oxygen, and a branched pipe leading air from the heat-exchanger to the column, an evaporator coil in the container interposed in one of said branches, and means for controlling the travel of the air through said branches whereby to regulate the intensity of vaporization in said container.

6. In apparatus for producing and delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and wherein the air is liquefied and separated into nitrogen and oxygen, a heat-exchanger wherein the air is cooled by travelling in proximity to the products, a plurality of vaporizing containers individually connected to the column for the admission of liquid oxygen from the latter and said containers being also individually connected to the heat-exchanger for the travel of oxygen gas from the containers to the heat-exchanger, and a valved passage leading from the upper end of each of said vaporizing containers to the low pressure side of the rectification column for returning any vaporized oxygen from the vaporizing containers to the column while said vaporizing containers are being filled with liquid oxygen, evaporating coils in said containers through which air is led to the column, and selective control means whereby the air may be cut off of one or more of said evaporating coils and the corresponding containers may be filled with liquid oxygen from the column while the contents of the remaining container or containers may be vaporized and caused to travel to the heat-exchanger.

7. In apparatus for producing and delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and wherein the air is liquefied and separated into nitrogen and oxygen, a heat-exchanger wherein the air is cooled by travelling in proximity to the products, a plurality of vaporizing containers individually connected to the column for the admission of liquid oxygen from the latter and said containers being also individually connected to the heat-exchanger for the travel of oxygen gas from the containers to the heat-exchanger, and a valved passage leading from the upper end of each of said vaporizing containers to the low

pressure side of the rectification column for returning any vaporized oxygen from the vaporizing containers to the column while said vaporizing containers are being filled with liquid oxygen, evaporating coils in said containers through which air is led to the column, and selective control means whereby the air may be cut off of one or more of said evaporating coils and the corresponding containers may be filled with liquid oxygen from the column while the contents of the remaining container or containers may be vaporized and caused to travel to the heat-exchanger, and whereby the supply of air to the column through the direct connection may be controlled to maintain the proper operation of the column.

8. In apparatus for producing and delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and wherein the air is liquefied and separated into nitrogen and oxygen, a heat-exchanger wherein the air is cooled by travelling in proximity to the products, a plurality of vaporizing containers individually connected to the column for the admission of liquid oxygen from the latter and said containers being also individually connected to the heat-exchanger for the travel of oxygen gas from the containers to the heat-exchanger, and a valved passage leading from the upper end of each of said vaporizing containers to the low pressure side of the rectification column for returning any vaporized oxygen from the vaporizing containers to the column while said vaporizing containers are being filled with liquid oxygen, evaporating coils in said containers through which air is led to the column, a direct air connection between the heat-exchanger and the column, and selective control means whereby the air may be cut off from the evaporating coils of one or more of the containers while they are being filled and may be caused to travel through the coils of the remaining containers to vaporize their contents and discharge the oxygen gas therefrom and the travel of air through the direct connection may be regulated to maintain the proper operation of the column.

9. In apparatus for producing and delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and wherein the air is liquefied and separated into oxygen and nitrogen, a heat-exchanger wherein compressed air is cooled and from which the cooled air is led to the column, a vaporizer connected to the column for the admission of liquid oxygen from the latter, a valved passage connecting the upper end of the vaporizer to the low pressure side of the rectification column for returning any vaporized oxygen to the column while the vaporizer is being filled with liquid oxygen, means for passing compressed air through the vaporizer for vaporizing the contents of the latter, said compressed air means being connected to the column, a pressure container connected to the outlet of the vaporizer, and selective means for controlling the travel of air from the heat-exchanger and from the vaporizer to the column.

10. In apparatus for producing and delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and wherein the air is liquefied and separated into oxygen and nitrogen, a heat exchanger wherein compressed air is cooled and from which the cooled air is led to the column, a plurality of vaporizers connected in parallel to the column for the admission of liquid oxygen from the latter, and a valved passage leading from the upper end of each of said vaporizers to the low pressure side of the rectification column for returning any vaporized oxygen from the vaporizers to the column while said vaporizers are being filled with liquid oxygen, means for passing compressed air through the vaporizers for vaporizing the contents of the latter, said compressed air means being connected to the column, a pressure container connected to the outlets of the vaporizers, and selective means for controlling the travel of air to the column through the vaporizers and through the heat-exchanger.

11. In apparatus for producing and delivering oxygen gas under pressure, the combination of a rectification column to which air is supplied and in which the air is liquefied and separated into oxygen and nitrogen, a container in which quantities of liquid air supplied from the column are segregated, a valved passage connecting the upper end of said container to the low pressure side of the rectification column for the return to said column of any gaseous oxygen in the container while the latter is being filled with liquid oxygen, and an evaporating coil in said container for the passage of air therethrough to vaporize the oxygen in said container, the air chilled in said coil being supplied to the column.

12. In apparatus for producing and delivering oxygen under pressure, the combination of a rectification column to which air is supplied and in which the air is liquefied and separated into oxygen and nitrogen, a low level container connected to the column for the gravity supply of liquid oxygen from the column to the container, a valve in said connection, a valved passage connecting the upper end of said container to the low pressure side of the rectification column for the return to said column of any gaseous oxygen in the container while the latter is being filled with liquid oxygen, an evaporator coil in said container for the passage of air to vaporize the contents of the container, said coil being connected to the column for the supply of liquid air thereto, and a valve for said coil whereby the container may be alternately supplied with liquid oxygen and communication with the column interrupted and the contents of the container vaporized.

13. In apparatus for producing and delivering oxygen under pressure, the combination of a rectification column to which air is supplied and in which the air is liquefied and separated into oxygen and nitrogen, a container connected to the column for the supply of liquid oxygen from the column to the container, a valve in said connection, a valved passage connecting the upper end of said container to the low pressure side of the rectification column for the return to said column of any gaseous oxygen in the container while the latter is being filled with liquid oxygen, an evaporator coil in said container for the passage of air to vaporize the contents of the container, said coil being connected to the column for the supply of liquid air thereto, and a valve for said coil whereby the container may be alternately supplied with liquid oxygen and communication with the column interrupted and the contents of the container vaporized.

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