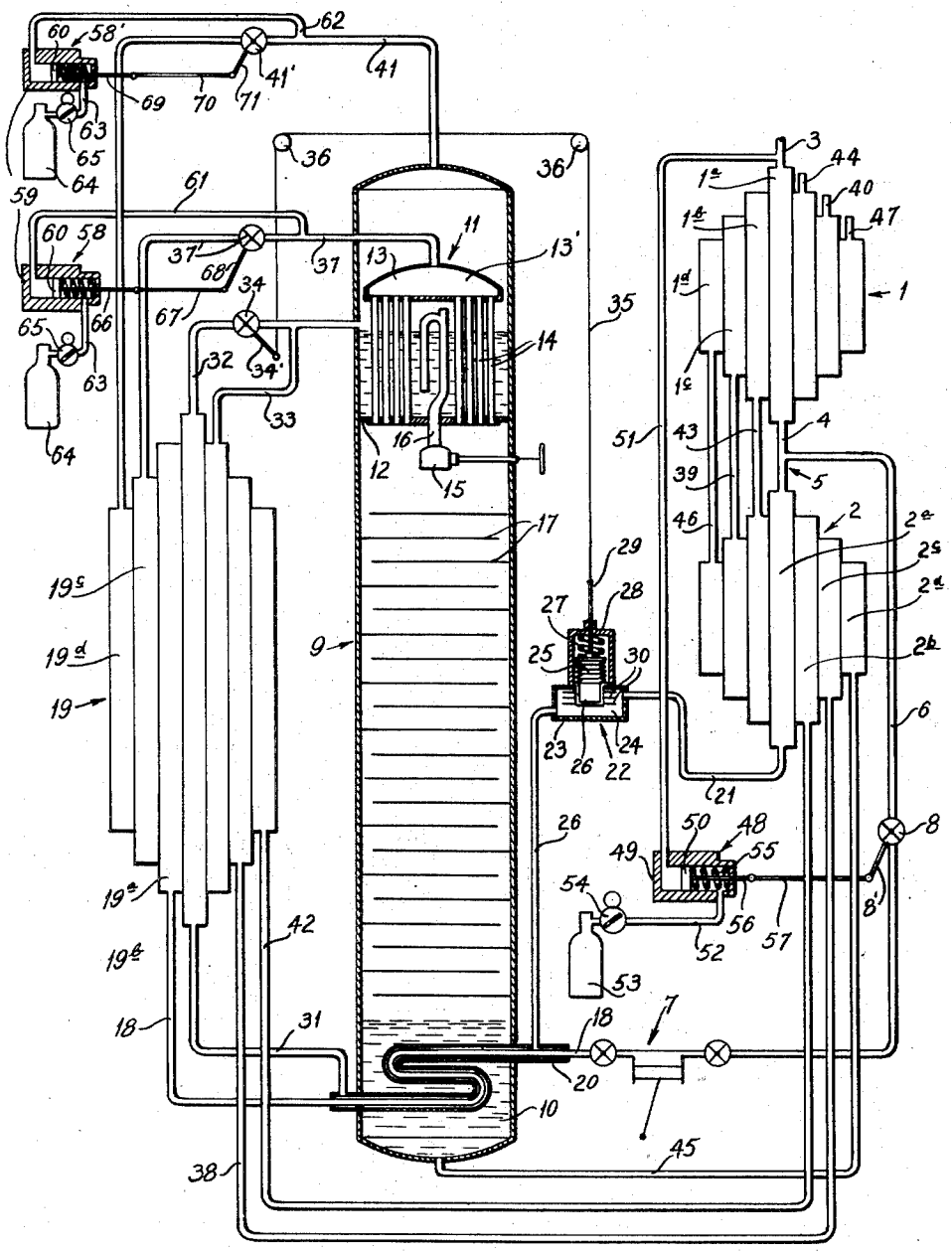
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APPARATUS FOR SEPARATING THE CONSTITUENTS OF ATMOSPHERE

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APPARATUS FOR SEPARATING THE CONSTITUENTS OF ATMOSPHERE

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This invention relates generally to apparatus for separating the constituents of atmosphere, and more specifically to a liquefaction and rectification column assembly adapted for use in separating from atmosphere and isolating, oxygen and nitrogen, the predominant object of the invention being to provide such a liquefaction and rectification column assembly which is so completely automatic in its operation that the need for constant attention of human operators during operation of the column assembly is dispensed with.

In the drawing, wherein the single view illustrates the improved apparatus diagrammatically, 1 designates a heat exchanger of suitable design, and 2 designates a suitable liquefier. Leading to the portion 1a of the heat exchanger is a conductor 3 which conducts air to the heat exchanger from a compressor (not shown) after said air has been subjected to the usual scrubbing and drying actions. The portion 1a of the heat exchanger 1 into which the incoming air is conducted by the conductor 3 is connected to a corresponding portion 2a of the liquefier 2 by a conductor 4, and connected into said conductor 4 at the point designated by the reference character 5 is a branch conductor 6. The branch conductor 6 leads from the conductor 4 to an expansion engine 7 and as a result of such arrangement part of the air moving from the heat exchanger 1 passes to the liquefier 2 through the conductor 4, and part of said air passes to the expansion engine 7 through the branch conductor 6, the point of division of said parts of said air being the point 5 where the conductors 4 and 6 are interconnected. The branch conductor 6 has interposed therein a valve 8 which is operable to control passage of air through said conductor to the expansion engine 7.

The assembly of the present invention includes a liquefaction and rectification column 9 which comprises the usual vertically disposed housing in the lower portion of which a boiling pot 10 is arranged for the reception of liquid oxygen resulting from the operation of the column. Arranged within the upper portion of the column 9 is a dephlegmator 11 which includes a bottom, horizontal wall 12 that is suitably supported by the housing of the column, and a hollow, upper head 13. The dephlegmator 11 includes, also, a nest of vertically disposed tubes 14 which are secured at their opposite ends to the lower wall of the head 13 and to the bottom, horizontal wall 12, so that said tubes communicate at their upper ends with the chamber 13' within the head 13,

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and at their lower ends with the interior of the column beneath the bottom, horizontal wall 12. Located within the column 9, below the bottom, horizontal wall 12 of the dephlegmator 11, is an expansion valve 15, said expansion valve being connected into the space above the bottom, horizontal wall of the dephlegmator by a tube 16. The column is provided, also, with the usual rectification trays 17 which serve a function well known to persons familiar with the art to which this invention relates.

Extended from the expansion engine 7 is a conductor 18 which extends into and through the boiling pot 10 of the column 9 and outwardly from said boiling pot to a portion 19a of a sub-cooler 19. The conductor 18 extends continuously from the expansion engine to the sub-cooler, and the portion of said conductor which is located within the boiling pot 10 of the column 9 is of tortuous formation as shown in the drawing. Arranged in embracing relation with respect to the tortuous portion of the conductor 18 which is located within the boiling pot of the column 9, and with respect to portions of said conductor located immediately outwardly of the housing of the column, is a tube 20 which is closed at its opposite ends and is of such diameter that an annular space is provided throughout said tube between the wall thereof and the wall of the portion of the conductor 18 which is embraced by said tube.

The annular space within the tube 20 is connected to the portion of the liquefier into which air is introduced by the conductor 4 by a conductor 21, and interposed in this conductor 21 is a temperature-responsive device 22. The particular temperature-responsive device 22 illustrated in the drawing comprises a lower housing portion 23 which provides a chamber 24 into which portions of the conductor 21 are connected, so that air passing from the liquefier 2 to the tube 20, through the conductor 21, will pass through the chamber 24. The temperature-responsive device 22 includes, also, a bellows-type diaphragm 25 which is secured at its lower end to a receptacle 26 which is fixed to, or is formed integral with, the lower housing 23, and extends downwardly into the chamber 24 of said lower housing. The interiors of the receptacle 26 and the diaphragm provide a chamber which contains petroleum vapor, or other suitable gas which liquefies only at very low temperature, there being a coil spring 27 interposed between the top wall of the diaphragm and the top wall of an upper housing portion 28 which embraces the dia-

phragm and said coil spring. The top wall of the diaphragm 25 of the temperature-responsive device 22 has fixed thereto a rod 29 that extends through an opening formed through the top wall of the upper housing 28 and which serves a purpose to be hereinafter set forth. Also, the receptacle 26 has formed thereon fins 30 that are disposed within the chamber 24 of the lower housing portion 23 and which provide said receptacle with additional cooling surfaces.

The annular space within the tube 20, between the wall thereof and the wall of the conductor 18, has connected thereinto a conductor 31 which leads from said tube to the bottom of a portion 19b of the sub-cooler 19, and from the upper portion of this same portion of the sub-cooler, a conductor 32 leads to the upper portion of the column 9, above the bottom, horizontal wall of the dephlegmator 11. Likewise, leading from the upper portion of the portion of the sub-cooler to the lower portion of which the conductor 18 leads, is a conductor 33 which is connected into the conductor 32. The conductor 32 has interposed therein an expansion valve 34 which is provided with an operating arm 34', and connected to this operating arm and to the rod 29 of the temperature-responsive device 22 is a flexible element 35 which passes over suitably located pulleys 36.

Connected into the chamber 13' of the head of the dephlegmator 11 is a pure nitrogen conductor 37, which is provided with a valve 37', and leads from said chamber 13' to the portion 19c of the sub-cooler 19, and from said sub-cooler portion 19c a conductor 38 leads to the portion 2c of the liquefier 2. In like manner, the portion 2c of the liquefier 2 is connected by a conductor 39 to the portion 1c of the heat exchanger 1, and an outlet conductor 40 leads from said heat exchanger portion 1c. Likewise, an impure nitrogen conductor 41, which is provided with a valve 41', leads from the top of the column to the portion 19d of the sub-cooler 19, and a conductor 42 leads from said sub-cooler portion 19d to a portion 2b of the liquefier 2, there being, also, a conductor 43 which leads from the liquefier portion 2b to the heat exchanger portion 1b, and an outlet conductor 44 which leads from said heat exchanger portion 1b. Also, the improved assembly includes an oxygen conductor 45 which leads from the boiling pot of the column 9 to the portion 2d of the liquefier 2, said liquefier portion 2d being connected by a conductor 46 to the portion 1d of the heat exchanger 1 and an outlet conductor 47 being provided which leads from said heat exchanger portion 1d through which oxygen is withdrawn.

The valve 8, which is interposed in the conductor 18 that leads to the expansion engine 7, is provided with pressure-responsive means 48 for operating said valve. This pressure-responsive means comprises a cylinder 49 provided with a piston 50 adapted for reciprocatory movement within said cylinder. A conductor 51 is connected at one of its ends into the air inlet conductor 3 of the heat exchanger and at its opposite end said conductor 51 is connected into the cylinder 49 at one side of the piston therein. Connected into the cylinder 49 at the opposite side of the piston 50 is a conductor 52, and this conductor 52 is connected, also, to a receptacle 53 which contains air, or other medium, under pressure. The conductor 52 has interposed therein a pressure regulator 54 which is operable, in an obvious manner, to maintain within the cylinder 49 at one side of the piston a predetermined pressure. Also, if desired, a coil spring 55 may be arranged within the cylinder 49 in interposed relation between the piston and a wall of the cylinder, so as to stabilize movement of the piston, and a rod 56 is fixed to the piston and extends through a wall thereof. The rod 56 is connected to the operating arm 8' of the valve 8 by a suitable connecting element 57.

The valve 37' which is interposed in the conductor 37, and the valve 41', which is interposed in the conductor 41, are provided with a pressure-responsive means 58 and 58' for operating said valves which are constructed and arranged in accordance with the pressure-responsive means 48 just described. In other words each of the pressure responsive means 58 and 58' comprises a cylinder 59 wherein a piston 60 is mounted for reciprocatory movement. A conductor 61 is connected at one of its ends into the conductor 37 and at its opposite end into the cylinder of the pressure-responsive means 58 at one side of the piston therein, while a conductor 62 is connected at its opposite ends into the conductor 41 and into the cylinder of the pressure-responsive means 58' at one side of the piston in said cylinder. Connected into the cylinders of the pressure-responsive means 58 and 58', at the sides of the pistons opposite to the sides thereof at which the conductors 61 and 62 enter said cylinders, are conductors 63 which lead from receptacles 64 that contain air, or other medium, under pressure, the conductor 63 of each of the pressure-responsive means 58 and 58' having interposed therein a pressure regulator 65 which serves to maintain a predetermined pressure within the cylinder at one side of the piston therein. The piston 60 of the pressure-responsive means 58 is provided with a rod 66 which extends through a wall of the cylinder and is connected by a connecting element 67 to the operating arm 68 of the valve 37', while the piston 60 of the pressure-responsive means 58' is provided with a similar rod 69 that extends through a wall of the cylinder and is connected by a connecting element 70 to the operating arm 71 of the valve 41'.

In the operation of the improved column assembly disclosed herein, air from a compressor, after being subjected to drying, scrubbing, and other desired preliminary actions, is admitted to the heat exchanger 1 by way of the conductor 3. After passing through the heat exchanger the air is divided at the point 5 of the conductor 4, part of said air being delivered by the conductor 6 to the expansion engine 7, and the remaining portion passing through the liquefier where it is additionally cooled. The air which passes through the liquefier passes through the conductor 21, said air moving through the chamber 24 of the temperature-responsive device 22 and eventually being discharged into the space within the tube 20 between the wall thereof and the wall of the conductor 18, whence it passes through the conductor 31 to and through the sub-cooler 19 and to and through the conductor 32 to the column 9.

The amount of air which is permitted to pass through the expansion valve 34 of the conductor 32 is controlled by the temperature-responsive device 22, inasmuch as the volume of the gas within the diaphragm of said temperature-responsive device will vary in accordance with changes in temperature of the air passing through the chamber 24 of said temperature-responsive device. This will subject the diaphragm to movement which will be transmitted to the operating

arm 34' of the expansion valve 34 by the element 35, so as to adjust said valve in accordance with the temperature of the air passing through the chamber 24 of the temperature-responsive device 22.

It is apparent, therefore, that with a constant volume of air ensuing from the compressor associated with the improved column assembly, that if the volume of air passing through the expansion valve 34 is diminished, more air must pass through the valve 8 to the expansion engine 7, or pressure in the system will raise. This is accomplished by setting the pressure regulator 54 to a predetermined pressure which acts against one side of the piston 50, within the cylinder 49, to maintain the valve 8 in such position that a predetermined volume of air is permitted to flow through said valve to the expansion engine, and when the pressure of the incoming air exceeds the pressure in the cylinder 49 which is controlled by the pressure regulator 54, the piston 50 will be moved by such greater pressure to operate the valve 8 so that a greater volume of air may pass to the expansion engine 7. In this manner constant pressure is automatically maintained in the system at all times during operation thereof.

Air from the expansion engine 7 passes through the conductor 18 and moves unrestricted through the sub-cooler 19 and into the dephlegmator 11 of the column 9 by way of the conductor 33. This allows air from the expansion engine to be expanded to zero pressure, or nearly so, and the full refrigeration effect is attained, while air from the liquefier, which passes through the conductor 21, the tube 20, the sub-cooler 19, and the conductor 32, is carried at full pressure to the expansion valve 34, where it is expanded with full refrigeration, and combines with the air from the expansion engine for delivery to the dephlegmator 11 of the column 9. Liquid from the dephlegmator 11 passes by way of the tube 16 to the expansion valve 15 from which it is discharged for descent through the column.

In like manner, the pressure-responsive means 58 and 58' automatically control operation of the valves 37' and 41' of the conductors 37 and 41. In other words the pressure regulators 65 of said pressure-responsive means 58 and 58' are set so that a predetermined pressure is maintained at one side of the piston 60 of each of said pressure-responsive means. This will maintain the valves 37' and 41' in predetermined positions, and when the pressures in the conductors 61 and 62 exceed the pressures for which the pressure regulators 65 are set the pistons 60 will be moved by such greater pressures to operate the valves to permit greater volumes of medium to pass through said valves and through the conductors with which they are associated.

We claim:

1. An apparatus for separating the constituents of a gaseous medium which includes a heat exchanger to which a gaseous medium under compression is delivered for reducing the temperature thereof, a liquefier, an expansion engine, conducting means for delivering part of the medium passing from said heat exchanger to said liquefier and for delivering part of said medium passing from said heat exchanger to said expansion engine, a valve for controlling passage of medium from said heat exchanger to said expansion engine and operable in response to changes in pressure of medium entering said heat exchanger, a liquefaction and rectification column, said column

having a boiling pot wherein liquid medium collects during operation of the apparatus, conducting means leading from said liquefier toward the upper portion of said column, a alve interposed in said conducting means which leads from said liquefier to the upper portion of said column and operable in response to temperature changes of medium passing through said conducting means, conducting means leading from said expansion engine toward the upper portion of said column, said conducting means leading from said liquefier and said conducting means leading from said expansion engine having independent portions which are disposed in said boiling pot of said column whereby the mediums passing through said conductor means portions which are of relatively high temperature will cause the liquid medium contained in the boiling pot of said column to give off vapor for upward movement through said column, conducting means common to and communicating with portions of the conducting means leading from said liquefier and the conducting means leading from said expansion engine which delivers the combined mediums passing from said liquefier and said expansion engine to the upper portion of said column, and a pure nitrogen conducting means leading from the upper portion of said column, a valve interposed in said pure nitrogen conducting means and operable in response to changes in pressure of the nitrogen passing through said pure nitrogen conducting means.

2. An apparatus for separating the constituents of a gaseous medium which includes a heat exchanger to which a gaseous medium under compression is delivered for reducing the temperature thereof, a liquefier, an expansion engine, conducting means for delivering part of the medium passing from said heat exchanger to said liquefier and for delivering part of said medium passing from said heat exchanger to said expansion engine, a valve for controlling passage of medium from said heat exchanger to said expansion engine and operable in response to changes in pressure of medium entering said heat exchanger, a liquefaction and rectification column, said column having a boiling pot wherein liquid medium collects during operation of the apparatus, conducting means leading from said liquefier toward the upper portion of said column, a valve interposed in said conducting means leading from said liquefier toward the upper portion of said column and operable in response to temperature changes of medium passing through said conducting means, conducting means leading from said expansion engine toward the upper portion of said column, said conducting means leading from said liquefier and said conducting means leading from said expansion engine having independent portions which are disposed in said boiling pot of said column whereby the mediums passing through said conductor means portions which are of relatively high temperature will cause the liquid medium contained in the boiling pot of said column to give off vapor for upward movement through said column, conducting means common to and communicating with portions of the conducting means leading from said liquefier and the conducting means leading from said expansion engine which delivers the combined mediums passing from said liquefier and said expansion engine to the upper portion of said column, a pure nitrogen conducting means leading from the upper portion of said column, a valve interposed in said pure nitrogen conduct-

ing means, an impure nitrogen conducting means leading from the top of said column, and a valve interposed in said impure nitrogen conducting means, said valves of said pure nitrogen conducting means and said impure nitrogen conducting means being operable respectively in response to pressure changes of medium passing through said pure nitrogen conducting means and said impure nitrogen conducting means.

3. An apparatus for separating the constituents of a gaseous medium which includes a heat exchanger to which a gaseous medium under compression is delivered for reducing the temperature thereof, a liquefier, an expansion engine, conducting means for delivering part of the medium passing from said heat exchanger to said liquefier and for delivering part of said medium passing from said heat exchanger to said expansion engine, a liquefaction and rectification column, said column having a boiling pot wherein liquid medium collects during operation of the apparatus, conducting means leading from said liquefier toward the upper portion of said column, conducting means leading from said expansion engine toward the upper portion of said column, said conducting means leading from said liquefier and said conducting means leading from said expansion engine having independent tortuous portions which are arranged one within another and are disposed in said boiling pot of said column whereby the mediums passing through said conductor means portions which are of relatively high temperature will cause the liquid medium contained in the boiling pot of said column to give off vapor for upward movement through said column, and conducting means common to and communicating with portions of the conducting means leading from said liquefier and the conducting means leading from said expansion engine which delivers the combined mediums passing from said liquefier and said expansion engine to the upper portion of said column.

4. An apparatus for separating the constituents of a gaseous medium which includes a heat exchanger to which a gaseous medium under compression is delivered for reducing the temperature thereof, a liquefier, an expansion engine, conducting means for delivering part of the medium passing from said heat exchanger to said liquefier and for delivering part of said medium passing from said heat exchanger to said expansion engine, a liquefaction and rectification column, said column having a boiling pot wherein liquid medium collects during operation of the apparatus, conducting means leading from said liquefier toward the upper portion of said column, conducting means leading from said expansion engine toward the upper portion of said column, said conducting means leading from said liquefier and said conducting means leading from said expansion engine having independent tortuous portions which are arranged one within another with an annular space between the walls thereof and are disposed in said boiling pot of said column whereby the mediums passing through said conductor means portions which are of relatively high temperature will cause the liquid medium contained in the boiling pot of said column to give off vapor for upward movement through said column, and conducting means common to and communicating with portions of the conducting means leading from said liquefier and the conducting means leading from said expansion engine which delivers the combined mediums passing from said liquefier and said expansion engine to the upper portion of said column.

5. An apparatus for separating the constituents of a gaseous medium which includes a heat exchanger to which a gaseous medium under compression is delivered for reducing the temperature thereof, a liquefier, an expansion engine, conducting means for delivering part of the medium passing from said heat exchanger to said liquefier and for delivering part of said medium passing from said heat exchanger to said expansion engine, a liquefaction and rectification column, said column having a boiling pot wherein liquid medium collects during operation of the apparatus, conducting means leading from said liquefier to the upper portion of said column, conducting means leading from said expansion engine to the upper portion of said column, said conducting means leading from said liquefier and said conducting means leading from said expansion engine having independent portions which are disposed in said boiling pot of said column whereby the mediums passing through said conductor means portions which are of relatively high temperature will cause the liquid medium contained in the boiling pot of said column to give off vapor for upward movement through said column, a valve interposed in said conducting means which leads from said liquefier to the upper portion of said column, and temperature-responsive means responsive to the temperature of medium passing through said conducting means for actuating said valve, said valve being disposed in said conducting means leading from said liquefier to the upper portion of column at a point adjacent to the upper portion of said column, and said temperature-responsive means being interposed in said conducting means at a point adjacent to said liquefier.

6. An apparatus for separating the constituents of a gaseous medium which includes a heat exchanger to which a gaseous medium under compression is delivered for reducing the temperature thereof, a liquefier, an expansion engine, conducting means for delivering part of the medium passing from said heat exchanger to said liquefier and for delivering part of said medium passing from said heat exchanger to said expansion engine, a liquefaction and rectification column, said column having a boiling pot wherein liquid medium collects during operation of the apparatus, conducting means leading from said liquefier to the upper portion of said column, conducting means leading from said expansion engine to the upper portion of said column, said conducting means leading from said liquefier and said conducting means leading from said expansion engine having independent portions which are disposed in said boiling pot of said column whereby the mediums passing through said conductor means portions which are of relatively high temperature will cause the liquid medium contained in the boiling pot of said column to give off vapor for upward movement through said column, a valve interposed in said conducting means which leads from said liquefier to the upper portion of said column, a temperature-responsive means responsive to the temperature of medium passing through said conducting means for actuating said valve, said valve being disposed in said conducting means leading from said liquefier to the upper portion of said column at a point adjacent to the upper portion of said column, and said temperature-responsive means being interposed in said conducting means at a

point adjacent to said liquefier, and means for transmitting motion from said temperature responsive means to said valve.

7. An apparatus for separating the constituents of a gaseous medium which includes a heat exchanger to which a gaseous medium under compression is delivered for reducing the temperature thereof, a liquefier, an expansion engine, conducting means for delivering part of the medium passing from said heat exchanger to said liquefier and for delivering part of said medium passing from said heat exchanger to said expansion engine, a liquefaction and rectification column, said column having a boiling pot wherein liquid medium collects during operation of the apparatus, conducting means leading from said liquefier toward the upper portion of said column, conducting means leading from said expansion engine toward the upper portion of said column, a subcooler having independent passageways therethrough which form parts of the conducting means leading from said liquefier toward the upper portion of said column and of the conducting means leading from said expansion engine toward the upper portion of said column, said subcooler serving to additionally reduce the temperature of medium passing therethrough, said conducting means leading from said liquefier and said conducting means leading from said expansion engine having independent portions

which are disposed in said boiling pot of said column whereby the mediums passing through said conductor means portions which are of relatively high temperature will cause the liquid medium contained in the boiling pot of said column to give off vapor for upward movement through said column, and conducting means common to and communicating with portions of the conducting means leading from said liquefier and the conducting means leading from said expansion engine which delivers the combined mediums passing from said liquefier and said expansion engine to the upper portion of said column.

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