

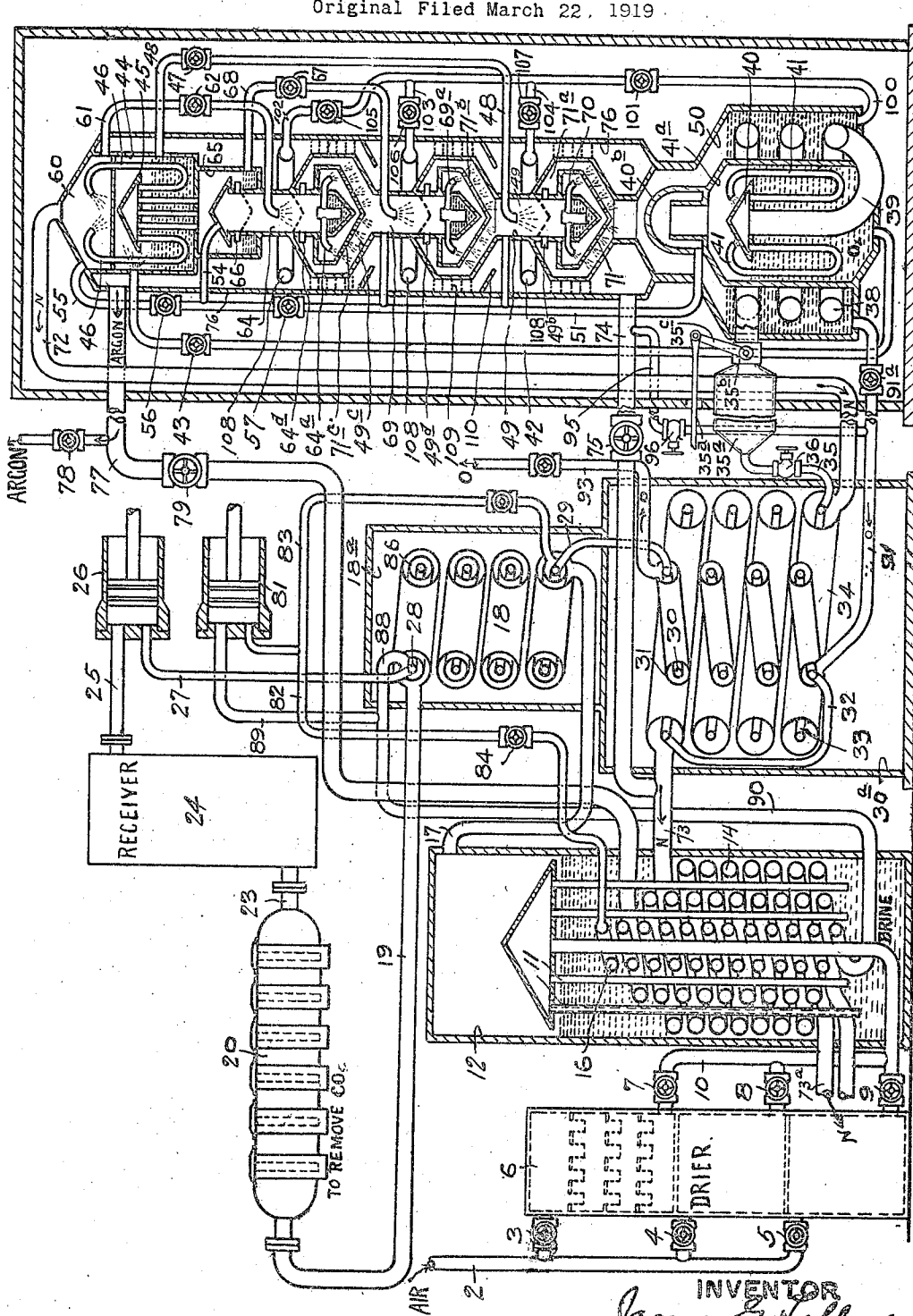
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APPARATUS FOR SEPARATION OF AIR INTO ITS CONSTITUENTS

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APPARATUS FOR SEPARATION OF AIR INTO ITS CONSTITUENTS.

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To all whom it may concern:

Be it known that I, JAMES G. LAFFERTY, a citizen of the United States, and resident of Coraopolis, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Apparatus for Separation of Air into Its Constituents; and I do hereby declare the following to be a full, clear, and exact description thereof.

My invention relates to apparatus for the production of pure oxygen, nitrogen and argon.

The object of my invention is to provide a simple and efficient form of apparatus by means of which air may be separated into its constituent elements by first liquefying.

In the accompanying drawing the figure illustrates a sectional elevation of my improved apparatus.

The numeral 2 designates a pipe supplied with air from a suitable blower (not shown), said pipe being connected up to a suitable preliminary dehydrating apparatus 6, which it has not been deemed necessary to illustrate in detail. The pipe 2 is provided with the valves 3, 4 and 5, leading to different points in the apparatus 6, and the supply of air may be regulated to any section of the apparatus, as clearly illustrated in the drawing. The air passes from the preliminary dehydrating apparatus 6 by the pipe 10, provided with valves 7, 8 and 9, to a chamber 12, which contains a nest of tubes 11 which are submerged in a suitable brine contained within the chamber 12. The air passes downward through the tubes 11 and bubbles up through the brine in the chamber 12, the brine being at such a low temperature that the dehydrated air is not moistened. A pipe 17 leading from the top of chamber 12 is connected up to the coil 18 of suitable heat-interchanging apparatus contained within the casing 18^a, and a pipe 19 leads from this coil 18 to a suitable apparatus 20 for removing the last traces of CO₂ from the air. A pipe 23 connects the apparatus 20 with the receiving tank 24 in which the air is allowed to accumulate, and from which it is carried by the pipe 25 to the compressor 26. The air when compressed to a suitable pressure by the compressor 26, is delivered by the pipe 27 to the coil 28 surrounded by the coil 18 with an interme-

diate coil 86 to be referred to more fully later. In this manner the air contained in the coil 28 is cooled by the air supplied by the pipe 17 to the coil 18.

A pipe 29 is connected to the outlet of the coil 28, and said pipe is connected to the coil 30 in the chamber 30^a and the air contained within said coil is cooled by the gases in the coil 31 which are conducted from the apparatus hereinafter described.

The pipe 32 is connected at one end to the coil 30 and connects at the other end with a coil 33 contained in the interchanging coil 34, which said coil 33 is connected to the pipe 35 provided with the valve 36. The pipe 35 leads into the expander 35^a which is connected to the expanding coil 38. A valve 35^b is provided which is opened and closed at regular intervals by the lever 35^c connected up by the rod 35^d to a suitable reciprocating device, not shown. The air on entering the container 35^a increases in volume, and is expanded into the coil 38 where a reduction of temperature takes place. By the use of the container 35^a a greater volume of air is expanded at each operation. The container 35^a communicates by means of a suitable pipe with an expanding coil 38 contained in the low pressure liquid air chamber 50. Within the chamber 50 is the high pressure chamber 41^a, and a pipe 39 connected to the coil 38 enters said chamber 41^a and by means of the U-shaped branch-pipes 41 communicating with the chamber 40 at the upper end of the pipe 39, the air liquefied in the pipe 39 passes by said branch-pipes into the chamber 41^a.

The chamber 41^a communicates with the dome 40^b for the reception of the volatile gases arising from the chamber 41^a, and said gases, rich in nitrogen, will pass off by the pipe 51 to be carried upwardly and delivered by the branch-pipes 54 and 55 to different points of the apparatus, for the reasons more fully hereinafter set forth. This pipe 51 is provided with the valves 56 and 57.

The liquid air which collects in the chamber 41^a is conducted by the pipe 42, provided with the valve 43, to the chamber 44 of a condenser at the upper end of the main chamber 76, this condenser being composed of the superposed chambers 44, 60 and 65. A pipe 48 conveys the liquid from the chamber 44 to the chamber 49 said pipe 48 being

provided with the valve 47. The liquid which collects in the lower part of the chamber 49 flows by the pipes 70 into the spraying device 71 and passes down into the chamber 50, said liquid in its passage meeting the more volatile gases arising from said chamber 50, by which the nitrogen is freed and said nitrogen passes up into the chamber 71^a, whence it escapes by the pipes 49^b into the chamber 49, where it meets the liquid discharged from the pipe 48 thereby freeing part of the volatile gases discharged by the pipe 48. The gases, rich in nitrogen, separated in this manner still continue their ascent, passing through the chamber 49, where they meet the liquid discharged by the spray 71^b. The liquid supplied to this spraying device 71^b comes from the chamber 69, where the liquid collects and flows therefrom by the branch-pipes 69^a. The pipe 68 is connected up to the chamber 65, said pipe being provided with a valve 67. The volatile gases pass up through the chamber 49 and pass by the pipe 49^a into the chamber 69, where they meet any liquid which may be discharged from the pipe 68 and further free the volatile gases in the liquid delivered from said pipe. Again, these volatile gases continue to ascend and meet the liquid sprayed from the spray 71^c contained within the chamber 49^c. The liquid for the spraying device 71^c is supplied from the liquid which accumulates in the chamber 64 and which flows therefrom by the branch-pipes 64^a. The liquid that collects in the chamber 64 is conducted thereto by the pipe 61, provided with a valve 62, from the chamber 60 at the upper end of the casing 76. The volatile gases pass up through the chamber 49^c and pass by the pipes 64^a into the chamber 64, where they meet the liquid discharged from the pipe 61 into said chamber, where a further release of the volatile gases contained in said liquid takes place, and said volatile gases continue on up and escape by the pipes 66 into the chamber 65. The liquid introduced by the pipe 61 is richer in nitrogen than the liquid introduced by pipe 68. These gases rich in nitrogen then pass up through the condenser 45 contained within the chamber 44, and cool this condenser to their own temperature, after which these gases pass down and up through the U-shaped pipes 64, and are delivered by said U-shaped pipes into the chamber 60 from which they are discharged through the pipe 72. Liquid rich in nitrogen can be supplied to the chamber 60 through pipe 55 by opening the valve 56, and this liquid is delivered by the pipe 61 to the chamber 64. Gases may also be discharged into the upper end of the chamber 64 by the pipe 54 connected up to the pipe 51, the valve 56 being closed. This gas, rich in nitrogen from the dome 40^b, entering the upper end of the chamber 64, passes out

through the outlets 66 into the chamber 65 and is there reduced in temperature through expansion, the pressure in chambers 64 and 65 being less than the pressure in the pipe 54, and this gas passes off through the pipes 45 and 46, chamber 60 and pipe 72 in the manner described above. If any liquid is condensed in the chamber 64 it is discharged into the rectifying tower through the pipe 68. The gases discharged through the pipe 72 pass to the coil 34 to cool the air in the coil 33. The gas then passes by pipe 73 into coil 14 which aids to cool the brine in chamber 12. From the coil 14 it passes by pipe 73^a to a suitable container or to the atmosphere as desired.

In the production of oxygen by my apparatus, the liquid oxygen that is contained in the chamber 50 is conveyed by the pipe 91 provided with the valve 91^a to the coil 31, which cools the air contained in the coil 30. This liquid oxygen is volatilized in its discharge through the coil 31 and passes out by the pipe 93 to a suitable container.

Where it is desired to recover the argon, the valves 75 and 91^a are closed. A pipe 100 is connected to the lower end of the chamber 50, and said pipe is provided with the valve 101. Branch-pipes 102, 103 and 104 lead from the pipe 100 and enter the main chamber 76, said pipes being provided with valves 105, 106 and 107. Each branch-pipe connects up with a circular pipe 108, which is perforated so that the liquid is delivered from said pipes into the main chamber 76. A series of perforated screens 109 are provided together with baffles 110, whereby the remaining gas is separated as the liquid descends, and the argon passes up in the chamber 76 and is discharged by the pipe 77 through the valve 78 into a suitable container. In this case the valve 79 would be closed. In this process of recovering argon the oxygen collects in the bottom of chamber 76 and may be conducted by pipes 74 and 95 to the pipe 91, the valve 96 being open. The oxygen then passes as before into the coil 31. When it is desired to add heat to the apparatus, the valve 75 is opened and valves 78, 101, 96 are closed. This allows part of the gas in coil 34 to pass by pipe 74 into the chamber 76 where it acts to heat the apparatus contained therein.

I also provide a suitable auxiliary refrigerating machine 81 which is used to cool the brine contained in the chamber 12. A pipe 82 extends from said refrigerating machine through the usual condenser, not shown to the coil 16 in the chamber 12, said pipe 82 being provided with an expansion valve 84. A pipe 83 also leads from the refrigerating device to the coil 86 in the chamber 18^a, a pipe 88 connecting this said coil with the pipe 89 leading back to the refrigerating machine. A pipe 90 connects with the lower

end of the coil 16 and leads back to the pipe 89 connecting said pipe 90 up with the refrigerating machine.

What I claim is:

1. In apparatus for the separation of liquid air, the combination of a chamber for containing liquid air, a second chamber surrounding the said liquid air chamber for collecting liquid separation products, a rectifying tower disposed above the said chambers and in communication with the said liquid-collecting outer chamber, a cooling chamber disposed above the said tower, and means for removing liquid from the said cooling chamber and for introducing the said liquid into the said tower.

2. In apparatus for the separation of liquid air, the combination of a chamber for containing liquid air, an outer chamber surrounding the said first-named chamber for containing liquid separation products, a coil disposed in the said outer chamber and communicating with the said inner chamber, means for introducing liquid air into the said inner chamber through the said coil, a rectifying tower disposed above the said chambers and in communication with the said liquid-collecting outer chamber, a cooling chamber disposed above the said tower, and means for removing liquid from the said cooling chamber and for introducing the said liquid into the said tower.

3. In apparatus for the separation of liquid air, the combination of an inner high-pressure chamber for containing liquid air, an outer-low-pressure chamber for containing liquid separation products, a coil disposed in the said outer chamber and communicating with the said inner chamber, means for introducing liquid air into the said inner chamber through the said coil, a rectifying tower disposed above the said chambers and communicating with the said outer chamber, a cooling chamber disposed above the said tower, means for conveying liquid from the bottom of the said inner chamber to the said cooling chamber, and means for removing liquid from the said cooling chamber and for introducing the said liquid into the said tower.

4. In apparatus for the separation of air, the combination of a chamber for receiving liquid air, a chamber surrounding the first-named chamber for receiving liquid separation products, a rectifying tower disposed above the said chambers and communicating with the said outer chamber, a dome formed on the said inner chamber, a liquid receiver disposed in the said dome, and means for conveying liquid from the said receiver to the top of the said tower.

5. In apparatus for separating liquid air, the combination of an inner high-pressure chamber for containing liquid air, an outer low-pressure chamber surrounding the said

inner chamber for receiving liquid separation products, a coil disposed in the said outer chamber and communicating with the said inner chamber, means for introducing liquid air into the said inner chamber through the said coil, a rectifying tower disposed above the said chambers and communicating with the said outer chamber, a dome formed at the top of the said inner chamber, a liquid receiver disposed in said dome, and means for conveying liquid from the said receiver to the interior of the said tower.

6. In apparatus for separating liquid air, the combination of a chamber for receiving liquid separation products, a rectifying tower disposed above and in communication with the said chamber, the said tower comprising a central chamber or passage, means for causing liquid air to fall freely within the said passage, means for introducing gaseous separation products into the said passage, means at the bottom of the said passage for collecting liquid, and means for causing the liquid so collected to fall in a spray into the said receiving chamber below the said rectifying tower.

7. In apparatus for the separation of liquid air, the combination of a chamber for receiving liquid separation products, a rectifying tower disposed above and in communication with the said chamber, the said tower comprising a plurality of superposed sections, each section communicating with the section above and below it through a central chamber or passage of less width than the intermediate width of the said sections, means for introducing liquid air into each of the said passages, means for admitting gaseous separation products into each of the said passages, means disposed at the bottom of each of the said passages for collecting liquid, and means for causing the liquid so collected to fall in a spray into the subjacent passage.

8. In apparatus for separating liquid air comprising a chamber for receiving liquid separation products, a rectifying tower disposed above and in communication with the said chamber, the said tower comprising a plurality of superposed sections communicating with one another by means of central chambers or passages of less width than the width of the said sections, the walls of each of the said passages being continued into the subjacent section and terminating in a liquid collector, a spray device surrounding the lower end of each of the said passages, means for permitting liquid to flow from each of the said collectors into and through the surrounding spray member, means for admitting liquid air into each of the said passages, and means for admitting gaseous separation products into each of the said passages.

9. In apparatus for the separation of liquid air, the combination of a rectifying tower, a cooling chamber disposed at the top of the said tower, and a pipe for removing liquid from said cooling chamber and for introducing the said liquid into an intermediate part of the said tower.

10. In apparatus for the separation of liquid air, the combination of a rectifying tower, a cooling apparatus disposed at the top of the said tower and comprising a plurality of superposed sections, means for collecting liquid in certain of the said sections and means for removing the said liquid separately from each of the said sections and for introducing the said liquid into the said tower at different elevations therein.

11. In apparatus for the separation of liquid air, the combination of a rectifying tower, a cooling apparatus disposed at the top of the said tower and comprising three superposed sections, means for introducing liquid air into the central section of the said cooling apparatus, means for admitting gaseous separation products into the lower section and for conducting the said products through the intermediate section into the upper section, means for separately removing liquid from each of the said three sections and for introducing the liquid so removed into the said rectifying tower at three separate elevations therein.

12. In apparatus for the separation of liquid air, the combination of a rectifying column, a cooling apparatus disposed at the top of the said column, means for introducing liquid air into the central section of the said condenser, means for admitting gaseous separation products into the lower section thence through pipes contained in the intermediate section and into the upper section, means for conveying liquid from the said intermediate section into the said tower at the lower part thereof, means for conveying liquid from the said lower section into the said tower at an intermediate part thereof, and means for conveying liquid from the said upper section into the said tower at an upper part thereof.

13. In apparatus for the separation of liquid air, the combination of a liquid-receiving chamber, a rectifying tower disposed above and in communication with the said chamber, a cooling chamber disposed at the top of the said tower, and a casing surrounding the said tower and spaced therefrom, the said casing being attached to the said receiving chamber and to the said cooling chamber.

14. In apparatus for the separation of

liquid air, the combination of a liquid-receiving chamber, a rectifying tower disposed above and in communication with the said chamber, a cooling chamber disposed at the top of the said tower, a casing surrounding the said tower and spaced therefrom, the said casing being attached to the said receiving chamber and to the said cooling chamber, baffles disposed within the said casing and means for conveying liquid from the said receiving chamber into the space between the said casing and the said tower.

15. In apparatus for the separation of liquid air, the combination of a liquid-receiving chamber, a rectifying tower disposed above and in communication with the said chamber, a cooling chamber disposed at the top of the said tower, a casing surrounding the said tower and spaced therefrom, the said casing being attached to the said receiving chamber and to the said cooling chamber, baffles disposed within the said casing and means for introducing liquid from a common source of supply at different heights within the space between the said casing and the said tower.

16. In apparatus for the separation of liquid air, the combination of a liquid-receiving chamber, a rectifying tower disposed above and in communication with the said chamber, a cooling chamber disposed at the top of the said tower, a casing surrounding the said tower and spaced therefrom, the said casing being attached to the said receiving chamber and to the said cooling chamber, baffles disposed within the said casing, spray devices disposed at vertical intervals in the space between the said casing and the said tower, and means for conveying liquid from the said liquid receiving chamber to each of the said spray devices.

17. In apparatus for the separation of liquid air, the combination of a liquid-receiving chamber, a rectifying tower disposed above and in communication with the said chamber, a cooling chamber disposed at the top of the said tower, a casing surrounding the said tower and spaced therefrom, means for conveying gas from the said cooling chamber into the bottom of the said casing and means for conveying gas from an upper portion of the said casing to aid in cooling air entering the said apparatus.

In testimony whereof I, the said JAMES G. LAFFERTY, have hereunto set my hand.

JAMES G. LAFFERTY.

Witnesses:

H. HECK.

ROBT. R. TOTTEN.