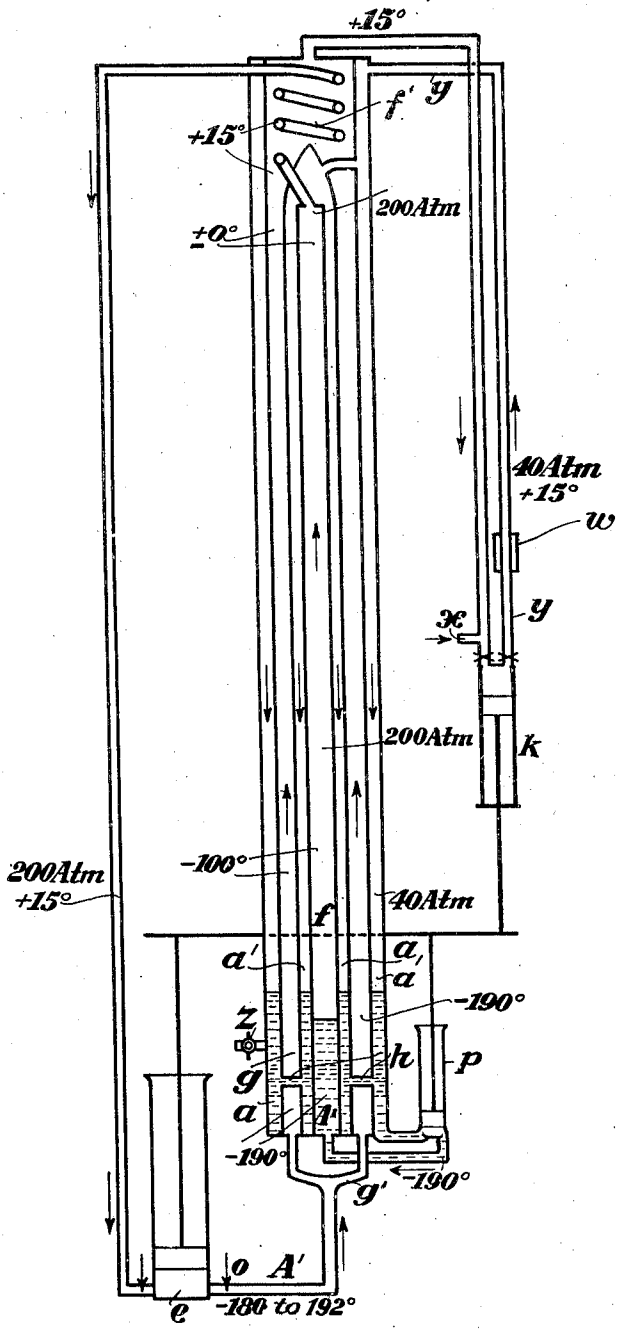
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P. HEYLANDT

APPARATUS FOR PRODUCING LOW TEMPERATURES

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APPARATUS FOR PRODUCING LOW TEMPERATURES.

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To all whom it may concern:

Be it known that I, PAUL HEYLANDT, a citizen of the Germany Republic, and a resident of Sudende, near Berlin, Germany, have invented certain new and useful Apparatus for Producing Low Temperatures, of which the following is a specification.

This invention relates in general to processes and apparatus for producing low temperatures particularly for the liquefaction of gases. It relates more specifically to processes of this kind in which low pressure gas compressors are employed. Some of the novel features of the process are the following.

During the circulation of the gas two heat exchanging processes take place, gaseous air having a temperature of 15° Celsius and compressed to a pressure of 40 atmospheres is conducted through a heat exchanger in which it encounters two sources of cold. The one source of cold consists of liquid air that is compressed to a pressure of 200 atmospheres and imparts its cold to the said warm air or gas compressed by a compressor to 40 atmospheres. In thus yielding up its cold the liquid air becomes gaseous and its temperature is raised to 15° Celsius. It is conducted in this warm state and at its high pressure of 200 atmospheres into an expansion machine in which it expands whilst performing external work and cools down to from —180° to —192° Celsius. This cooled expanded air forms the second source of cold, to which the aforementioned air of a temperature of 15° Celsius compressed to 40 atmospheres is subjected. The said cooled expanded air, after yielding up its cold, is drawn in and recompressed by the compressor. Hence the air which issues from the gas compressor and, after circulating through the above described devices, returns to the gas compressor, is subjected during circulation to two heat exchanging processes which result from the path along which the air is conducted having the form of conduits placed one within the other or from the said path being so shaped as to turn back upon itself as it were a number of times.

In the known gas liquefying processes of Linde, Claude, and Mewes only a fraction of the gas passed on by the compressor is liquefied. In Lindes process for instance only about 10 to 15% of this gas is liquefied, whereas the present process enables as much as 100% of the gas compressed by the compressor to a pressure of 40 atmospheres to be liquefied.

To achieve this result with the processes employed hitherto it was necessary to use a gas compressor for 200 atmospheres.

In the present process the air compressed to 40 atmospheres is converted into a liquid state by the two said sources of cold so that only a comparatively small liquid compressor is required for the purpose of raising the pressure of the liquid to 200 atmospheres. In this way the advantage is gained that in place of a gas compressor of large volume a liquid compressor of small volume can be used, because the volume of a given quantity of air is 800 times smaller in a liquid state than in its gaseous state.

The present process will be described with reference to the accompanying drawing which represents diagrammatically a vertical section of a column comprising heat exchangers consisting of three tall annular chambers and a central cylindrical chamber. The drawing also illustrates diagrammatical vertical sections of a high and low pressure compressor and of an expansion machine and the conduits connecting the compressors and the expansion machine to the column.

The column contains two tall annular chambers a and and a^1 that are in communication with each other through a connecting pipe h. Between the two annular chambers a and a^1 is an intermediate annular chamber g, and the inmost annular chamber a^1 surrounds a central cylindrical chamber f which is connected by a spiral conduit f^1 and an exterior pipe to an expansion machine e located in the coldest part of the apparatus and from which expanded gas is conducted into the middle annular chamber g by means of branch pipes g^1. k is an air compressor that compresses air taken in from the outside atmosphere through the inlet x to a pressure of 40 atmospheres and forces it through a pipe y, and through a water cooler w (which cools the air that is heated by compression) into the annular chambers a and a^1. From the annular chambers a and a^1 the gas passes at the bottom of the column to another compressor p which is arranged to raise the pressure of liquid air, which will have formed at the bottom of the column when the process has been properly

started, from 40 atmospheres to 200 atmospheres. The liquid air drawn in by the pump p from the annular chambers a and a^1 under a pressure of about 40 atmospheres is forced against a pressure of 200 atmospheres into the heat exchanger f. As the upper parts of the column are comparatively warm the liquid air will commence evaporating after rising a short distance in f and the expansion due to the evaporation of the liquid air causes a pressure of 200 atmospheres to be maintained in f and in the pipe leading out of it. Thus while a small volume of liquid gas is transferred by the pump p to the chamber f and thus raised from a pressure of 40 atmospheres to 200 atmospheres a comparatively large volume of gaseous air is kept at a pressure of 200 atmospheres by the evaporation taking place in f.

The temperature of the cold evaporated air in f before reaching the top of the column will have been raised to 0° Celsius and this temperature will be increased still further in the helical pipe f^1 where it will reach 15° Celsius. The pressure in f and in the conduit leading to the expansion machine e, or to any other suitable form of expanding device such as a turbine, may be increased at will to a point that will suffice to cause its temperature to be lowered by its expansion in e—during which it also loses heat through performing external work—to the boiling point of liquid air, viz. —180° to —182° Celsius. The expanded cooled gas passes from the expansion machine e through the branched pipe g^1 into the annular chamber g of the heat exchanger and in passing through this chamber g the gas transfers its cold to the adjacent chambers a and a^1 and receives warmth from the air in these chambers to such an extent that it passes out at the top of the column at a temperature of 15° Celsius. Instead of passing into the atmosphere the air leaving the column at the top may be drawn in by the compressor k which as hereinbefore stated, also takes in fresh air or gas through the inlet x. The compressor k raises the pressure of the said gases to a comparatively low pressure that lies beneath the critical pressure (20 atmospheres in the case of hydrogen) which in the case under consideration is 40 atmospheres. The gases or air after being purified and cooled by water are conducted through the pipe y into the top of the heat exchanger where they pass downwards in the annular chambers a, a^1 and their temperature is lowered by the cold in g and f to about —192° so that the air will liquefy.

The liquid pump p maintains a continuous circulation by pumping the liquid air from the bottom of a, a^1 into the chamber f and thereby raises its pressure to 200 atmospheres.

The liquefied air or gas collecting in the annular chambers a, a^1 may be tapped off through a tap z.

Other advantages offered by this process in addition to those already mentioned are the following: The output of the apparatus required for carrying out the process, on account of the volume of gas to be dealt with being much smaller, may also be much smaller and hence much cheaper and simpler than in the cases of known processes; for in order to produce 20 litres of liquefied gas per hour it will now not be necessary to compress 150 to 200 cubic metres of air per hour but only about 16 cbm the whole of which is now liquefied in a novel manner and thus yields 20 litres of liquid.

Another advantageous point is that no high compression pressure need be produced by the gas compressor as it is only necessary to raise the pressure of the gas to be liquefied to the critical pressure which, in the case of air, is 40 atmospheres.

These two features operate to reduce the price of the apparatus to such an extent that it costs only 2/5 of the price of ordinary apparatus whilst giving the same output.

Another advantage is obtained by sending the cold air through the helical pipe f^1 at the top of the column instead of conducting it straight from the middle chamber f to the expansion machine e. This advantage consists in the fact that the air coming from the expansion machine e and passing up through the annular chamber between a and a^1, and which air ordinarily leaves the apparatus at a temperature below 0° Celsius without accomplishing any useful end, effects a preliminary cooling of the gases passing through the helical pipe f^1 to the expansion machine. The cold producing effect of the plant is thus enhanced.

I claim:—

A refrigerating apparatus comprising, in combination, a pair of concentrically disposed annular members forming an inner chamber and an outer chamber in communication with each other near their lower ends, said chambers being spaced apart to provide an intermediate chamber therebetween and said inner chamber enclosing a space forming a cylindrical central chamber, an expansion machine disposed below said chambers, a tubular coil in communication with said central chamber at the upper end thereof and with said expansion machine, a pipe communicating with said expansion machine and with said intermediate chamber at the lower end thereof, a compressor in communication with the atmosphere and adapted to compress air to a pressure of 40 atmospheres, a water cooler, a pipe in communication with said compressor and passing through said water cooler, said pipe communicating with said outer and inner cham-

bers at the upper ends thereof, and a second compressor in communication with said outer chamber and said central chamber at their lower ends and adapted to receive a fluid from the outer chamber and transfer it to the central chamber under a pressure of 200 atmospheres.

In testimony whereof I have signed this specification in the presence of two witnesses.

PAUL HEYLANDT.

Witnesses:
KAPHE LEECH,
MAX JABLOUSKI.