

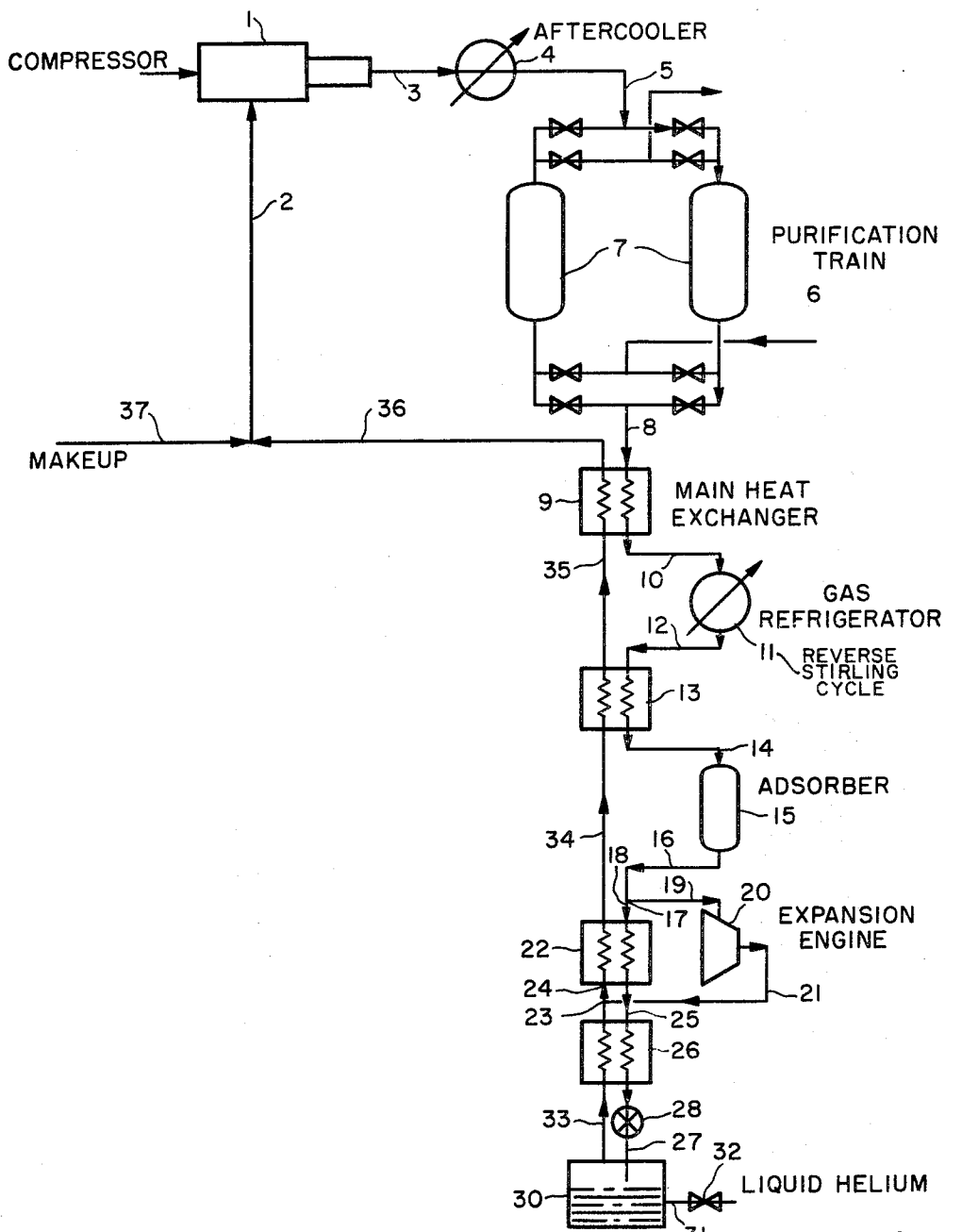
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APPARATUS FOR LIQUEFYING HELIUM

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APPARATUS FOR LIQUEFYING HELIUM

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1 Claim. (Cl. 62—38)

The present invention relates to a plant for liquifying helium which is fed into the plant at substantially atmospheric pressure and at ambient temperature. In addition, the present invention relates to a helium refrigerator which is simple in construction and reliably effective for the purposes intended.

It is an object of the present invention to provide a plant that functions, without modification, as a helium liquifier or a helium refrigerator.

Another object of the present invention is to provide a helium liquifier that may be utilized as a helium recondenser or a liquifier of impure helium without risking the chance of contaminating the internal structure of the apparatus.

The above and other features, objects and advantages of the present invention will be fully understood from the following description considered in connection with the accompanying illustrative drawing.

The sole figure of the drawing constitutes a flow diagram of the method of liquifying helium and the helium refrigerator constructed in accordance with the teachings of the present invention.

Referring to the sole figure of the drawing, helium at atmospheric pressure and ambient temperature is fed through pipe 2 to compressor 1. The helium gas is compressed in compressor 1 to about 200 p.s.i.a. and exits out of the pipe 3 and is directed into after cooler 4 in which the compressed helium which is at an elevated temperature is cooled to approximately ambient temperature. The gas is then conducted through pipe 5 to the purification train 6 which, for example, are shown to be a pair of charcoal adsorbers 7 that are alternately regenerated and on-stream. It should be noted that the purification train is optional depending upon whether or not the helium has been contaminated in the compressor 1. Also, it is within the scope of the present invention to employ other types of purification devices which are compatible with the present apparatus.

The compressed helium then leaves the purification train 6 and enters the main heat exchanger 9 through pipe 8. The compressed helium, cooled by the returning low pressure helium to approximately -320°F. , leaves the heat exchanger 9 and enters the refrigerator 11 through pipe 10. In the present apparatus the refrigerator 11 is of the cold gas type operating on the reverse Stirling cycle. The helium is cooled to approximately -352°F. in the refrigerator 11 and enters heat exchanger 13 by means of pipe 12. In this heat exchanger the helium gas is cooled by the returning low pressure helium to about -420°F. and exits through pipe 14. The helium gas then passes through an optional charcoal adsorber 15 to remove the last traces of impurities that may be present.

The gas leaves the adsorber 15 through pipe 16, the gas being split into two fractions at 17 in which about 58% flows through conduit 19 into expansion engine 20. It should be noted that the present invention is not dependent upon the type of expander used in this cycle and that within the scope of the present invention other expanders may be used, for example, reciprocating, turbo or the centrifugal type. In the present construction the helium gas is expanded in expansion engine 20 to approximately atmospheric pressure and the outlet temperature

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will depend upon the efficiency of the expansion engine 20. The temperature at point 21 is about -436°F. The outlet of the expansion engine 20 joins the returning helium at point 23 and enters heat exchanger 22 through conduit 24. The high pressure gas exits from heat exchanger 22 at about -435°F. and enters heat exchanger 26 through pipe 25. The gas is further cooled in heat exchanger 26 to approximately 446.5°F. by the returning helium and is discharged through conduit 27 having a throttle valve 28 therein. The helium gas is expanded through the throttle valve 28 to about atmospheric pressure wherein a portion of the gas forms a liquid. The liquid helium portion is removed from the pot 30 by means of a pipe 31 and a valve 32.

The vapor portion is separated from the liquid in pot 30 and returns to the compressor through heat exchangers 26, 22, 13 and 9 and exits from the heat exchanger 9 by means of a pipe 36 at approximately ambient temperature since its refrigeration was given up to the incoming helium.

Make-up helium to the extent of the quantity drawn off as a liquid at valve 32 is added to the system by means of the conduit 37.

It is also possible, without plant modification, to convert the above-described helium liquefier into a helium refrigerator. This is accomplished by preventing the liquid helium from being removed from the system by closing valve 32 and evaporating the helium by the heat load in pot 30, and therefore all the helium is recirculated and no make-up helium is required. Conversely, if liquid helium is withdrawn through line 31 and valve 32 and make-up added through pipe 37 the plant performs as a helium liquifier. Typical conditions of the present apparatus are as follows:

Head pressure	200 p.s.i.a.
Suction pressure	1 atm. absolute.
Inlet to gas refrigerator	-320°F.
Inlet to expansion engine	-420°F.
Outlet of expansion engine	-436°F.
Flow to expansion engine	58%.

While I have shown and described the preferred embodiment of my invention, it will be understood that the latter may be embodied otherwise than as herein specifically illustrated or described and that in the illustrated embodiment certain changes in the details of construction and in the arrangement of parts may be made without departing from the underlying idea or principle of the invention within the scope of the appended claim.

What I claim is:

An apparatus for liquefying helium comprising a compressor for gaseous helium supplied to it including make-up gaseous helium, a cooler for the compressed gaseous helium for cooling the same to approximately ambient temperature, alternately operable adsorbers for said gaseous helium exiting from said cooler, a first heat exchanger through which said gaseous helium traverses for cooling the same to a low temperature, a refrigerator operating on the reverse Stirling cycle and having said gaseous helium traversing therethrough wherein said gaseous helium is further cooled, a second heat exchanger for said cooled gaseous helium wherein the same is further cooled to approximately -420°F. , an additional adsorber following said second heat exchanger, said gaseous helium exiting from said additional adsorber and being split into two fractions, an expansion engine adapted to receive one of said fractions, a third heat exchanger for receiving the other of said fractions, a fourth heat exchanger, said one of the gaseous helium fractions in said expansion engine joining the returning gaseous helium and traversing the third, second, and first heat ex-

changers respectively and being conducted back to said compressor, the other of said gaseous helium fractions being further cooled in said fourth heat exchanger, a throttle valve for expanding said other gaseous helium fraction to about atmospheric pressure wherein at least a portion thereof forms liquid helium, and a pot for receiving said liquid helium, the vapor portion thereof returning to said compressor through said fourth, third, second and first heat exchangers respectively.

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