

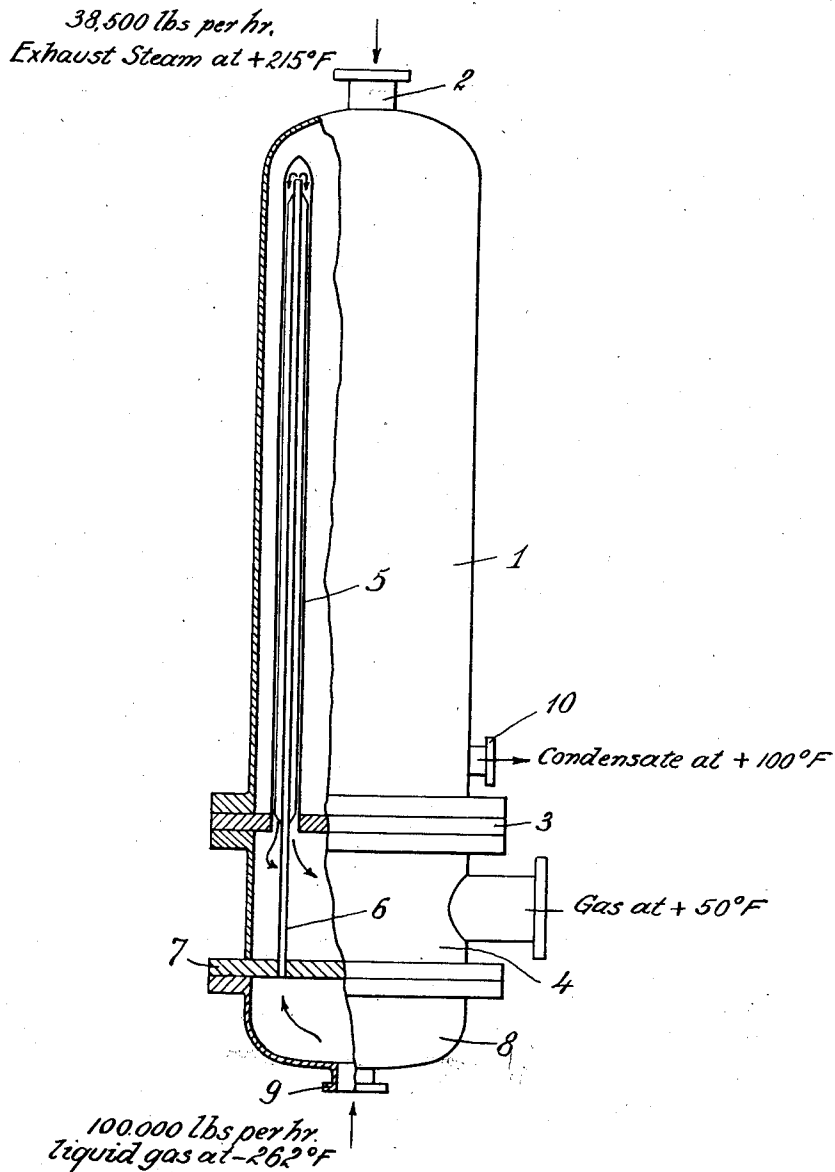
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EVAPORATION OF LIQUEFIED GASES

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EVAPORATION OF LIQUEFIED GASES

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The use of what are commonly known as liquefied gases has become important in recent years in several industries. For example, methane gas is liquefied and stored or transported in liquid form for use in fortifying fuel gas, and in order to so use it the liquefied gas must be restored to the gas phase. Liquefied gases of this character have boiling points at atmospheric pressure as low as -260° F. and the evaporation of such liquefied gases to the gaseous phase offers certain practical difficulties which have not heretofore been entirely solved. For the cheap and economic evaporation of any liquid, steam is usually the most satisfactory heating medium, particularly in industrial plants where exhaust steam is available for auxiliary purpose as is frequently the case.

Former attempts to utilize steam as a heat medium for the evaporation of liquefied gases has met with considerable difficulty because of the tendency of the condensed steam to freeze into ice on the heat transfer surface and thus greatly reduce its efficiency. This is particularly true when it is attempted to use low pressure saturated steam at atmospheric pressure which necessarily involves the condensation of considerable quantities of water on the heat transfer surface of the evaporator.

By my improved process hereinafter described I am able to utilize steam as the heating medium without any difficulties from ice formation.

The essential step in my process, the carrying out of which I will describe in some detail hereinafter in connection with an apparatus which I have found suitable for the purpose, consists in interposing between the low-boiling liquid being evaporated and the steam employed to supply the heat of vaporization, a layer of the gas resulting from the evaporation of the cold liquid. By this procedure the heat required for the vaporization of the cold liquid is not absorbed directly from the heating steam with consequent condensation and freezing, but is instead absorbed by the gas or vapor of the cold liquid which of course has no tendency to freeze on the cold surface in contact with the liquid.

By my improved process all surfaces exposed to the contact of the low temperature liquid are out of contact with the steam employed to supply the vaporizing heat and between the two is interposed a passage for the vapor of the low-boiling liquid.

The outer surface of the tubes or other passage through which the cold liquid is circulated will necessarily remain at temperatures but little

above the boiling point of the cold liquid due to the high rate of transfer of heat from a liquid to the metal of the tube or pipe in which it is circulated. The rate of heat transfer from a gas to the metal of the pipe or tube through which it is circulated, however, is very much lower than the rate of transfer of heat from a liquid to a contacting surface, and consequently although the temperature of the gas or vapor of the low temperature liquid may be well below the freezing point of water, the rate of heat absorption by the gas is so much lower than the rate at which heat is absorbed by the metal of the tubes from the surrounding steam that the temperature of the outer surface of the tubes will not be sufficiently lowered to freeze the condensate into ice.

In the accompanying drawing I have illustrated an apparatus which I have found in practice to be highly satisfactory for carrying my improved process into effect.

In the drawing, the apparatus is shown partly in section and partly in side elevation.

As shown, the apparatus consists of a vertical shell 1 into which the steam is preferably introduced through an inlet port 2 at the top. Beneath the shell 1 and separated from it by tube sheet 3 is an outlet chamber 4 for the vapor of the cold liquid. Supported in the tube sheet are dead end tubes 5 extending substantially to the top of the shell, and projecting axially of the tubes 5 to a point adjacent their dead ends are inner tubes 6 preferably provided with longitudinal or spiral fins for increasing the heat transfer surface which is in contact with the fluid flowing in the space within tube 5 surrounding the inner tube 6.

The inner tubes 6 extend across the vapor outlet chamber 4 into a second sheet 7 which forms the bottom of the vapor outlet chamber 4 and separates that chamber from the cold fluid inlet chamber 8 which constitutes the bottom of the apparatus. The chamber 8 is provided with an inlet port 9 for the cold liquid, and the shell 1 is provided near the bottom adjacent the tube sheet 3, with a discharge outlet 10.

In carrying out my improved process in this apparatus the sub-zero liquid is introduced through the port 9 and passes upwardly through the tubes 6 wherein it is vaporized by the heat absorbed from the vapor in the space between the inner tubes 6 and the outer tubes 5. This vapor is in turn heated by the condensation of steam on the outer surface of the tubes 5 and as the absorption of heat from the condensed steam

takes place at a much more rapid rate than the transfer of heat from the inner face of the tube surfaces to the vapor of the cold liquid, the temperature of the metal of the tubes is much nearer the temperature of the fluid in contact with their outer surfaces and consequently the condensate on the outer surfaces of the tubes 5 will not be reduced in temperature to a point below the freezing point of water. In other words, the temperature of a metal heat transfer wall which is so thin as to have an insignificant temperature gradient maintains a temperature intermediate the temperatures of the two fluids contacting its opposite surfaces such that the temperature difference between the surface and the hotter fluid times the rate of absorption from the hotter fluid will equal the temperature difference between the metal and the cold fluid times the rate of heat absorption by the colder fluid.

In order that the heat absorbed from the vapor of cold liquid within the outer tube space may be as rapid as possible it is preferable to provide the inner tubes 6 with heat-conducting fins which may be either longitudinal as shown, or spiral. The tubes 5 should be long enough in proportion to the rate of throughput of the liquid for the liquid to be substantially all vaporized in the inner tubes 6 so that no cold liquid will contact any portion of the surface exposed to the heating steam. Also, preferably the tubes 5 extend at their upper ends to a point in close proximity to the steam inlet so that at the point

where the fluid within the tube is at its lowest temperature the surrounding water vapor will be at its highest temperature and many degrees above freezing point.

In the accompanying drawing I have indicated a typical example of the working of my process by indicating at each port the quantity and temperature of the fluid entering the port or delivered from it, as the case may be. In this example the sub-zero liquid being evaporated is methane and the steam used is exhaust steam from the pump engine.

I claim:

1. The method of vaporizing liquefied gases having a boiling point at atmospheric temperature below 0° C. which consists in supplying said liquid to a heat exchanger, supplying steam to said heat exchanger, and maintaining an intermediate heat transferring layer of the vaporized liquid between the surface of the cold liquid passage and the surface exposed to the steam.

2. The method of vaporizing liquefied gases having a boiling point at atmospheric temperature below 0° C. which consists in continuously discharging the sub-zero liquid through an extended passage having a heat-transferring surface, conducting the vapor discharged from said passage in an annular path completely surrounding said liquid passage and continuously heating said enveloping vapor through a heat-transferring surface surrounded by steam and out of contact with the sub-zero liquid.

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