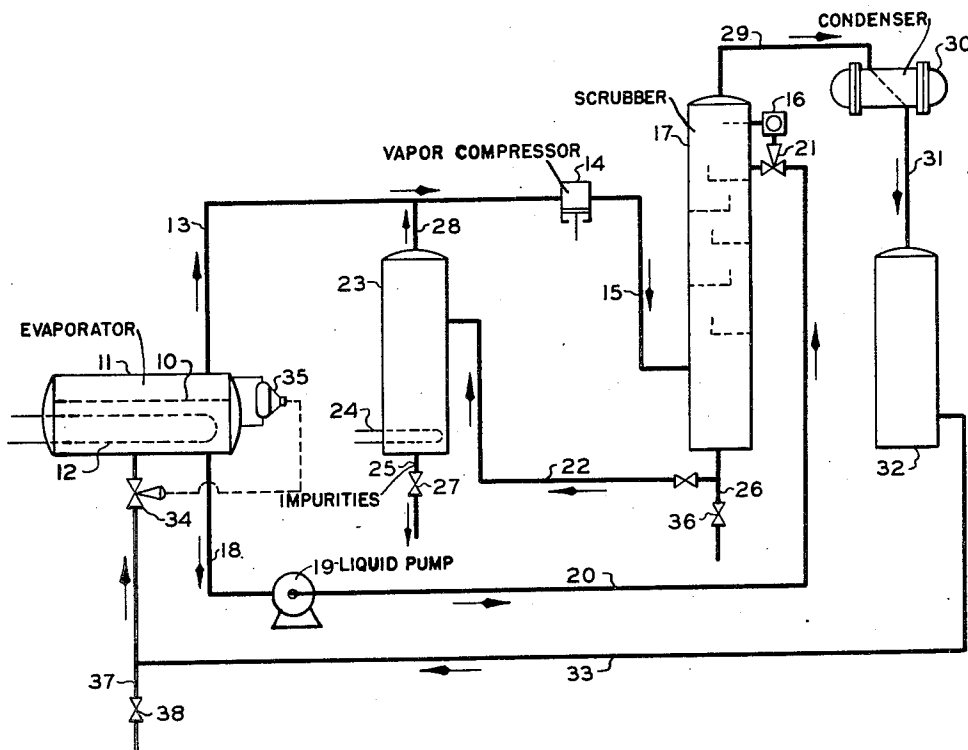


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CONTINUOUS REMOVAL OF IMPURITIES FROM REFRIGERANT
DURING A REFRIGERATION PROCESS
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CONTINUOUS REMOVAL OF IMPURITIES
FROM REFRIGERANT DURING A REFRIG-
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This invention relates to refrigeration. In one embodiment this invention relates to refrigeration processes utilizing a light hydrocarbon as a refrigerant. In a specific aspect, this invention relates to a refrigeration process wherein impurities constantly occurring in the refrigerant and adversely affecting the efficiency of the process, are continuously removed.

Various refrigeration methods are well known and commonly used in numerous industrial processes wherein heat exchange steps involving low temperatures are required. Refrigeration is a process of producing cold and involves a change of phase in a body so that it will be capable of abstracting heat. Such a body is commonly referred to as a refrigerant. Refrigerants usually are normally gaseous compounds which are readily compressed to the liquid state and which are in turn readily vaporized under the proper conditions. Refrigerants commonly used are ammonia, sulfur dioxide, methyl chloride, and light hydrocarbons such as propane and butane, and the like. Common refrigeration methods are dependent on a series of steps which include vaporization of liquid refrigerant in heat exchange relation to a substance to be cooled, compression of the expanded refrigerant by a mechanical compressor, cooling the resulting warm compressed refrigerant vapor, liquefaction, and return of the liquified refrigerant to the heat exchange step.

Compression refrigeration units are widely used in the petroleum industry, and especially in the extraction of natural gasoline from natural gases and in the fractionation of light hydrocarbon mixtures.

A refrigeration process is dependent upon numerous variables for its successful operation, among which is the selection of a proper refrigerant and heat exchange equipment, compressor design, and the like.

In any such refrigeration process the material to be cooled or refrigerated is passed through a tube bundle or coil which is surrounded by a refrigerant. The selection of the refrigerant is determined by the temperature to which the material in the coil is to be cooled. Generally, the refrigerant is selected so that its evaporation at atmospheric pressure or slightly greater, will produce the desired cooling temperature. Operation

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under subatmospheric pressure is usually not preferred because of excessive compression costs. For temperatures down to about 35° F. normal butane is satisfactory, while propane may be used for temperatures ranging down to about -40° F. For still lower temperatures, ranging down to about -250° F. or below, ethane is a suitable refrigerant. With a given refrigerant the exact temperature within the evaporator may be regulated by controlling the pressure under which the refrigerant evaporates.

Perhaps one of the major causes of lowered efficiency of a refrigeration process is the presence of impurities in the refrigerant proper. Such impurities are often inherently present in the refrigerant. This is especially true, in industrial practice, where a light hydrocarbon is utilized as the refrigerant. For example, when propane is so utilized, small quantities of butane are inherently present. In some instances of refinery operations, due to causes external to the refrigeration system, the propane refrigerant may contain several per cent butane. Another constant source of refrigerant contaminants, is the mechanical compressor, usually of the positive displacement type, which inherently introduces lubricating oil to the refrigerant by virtue of direct contact of the vapors with certain lubricated compressor parts. It is well known that hydrocarbons such as propane are excellent solvents for lubricating oils and consequently when a hydrocarbon refrigerant is compressed it tends to dissolve the oil used as lubricant in the compressor cylinder.

Higher boiling impurities present in the body of the liquid refrigerant cause a reduction of the vapor pressure of the refrigerant liquid and consequently a reduction in the quantity vaporized per unit time at a given temperature. The result is an overall lowered heat exchange efficiency. Heavier components of such impurities tend to form a coating on the surface of the heat exchange tubes and thereby seriously reduce the efficiency of heat transfer. Such depositions necessitate periodic shut downs to remove the adhered materials.

Economically undesirable operation of a refrigeration process results when higher molecular weight impurities are present in the liquid refrigerant, and this invention is concerned with

a method for substantially completely preventing the presence of such impurities.

An object of this invention is to provide an improved refrigeration method.

Another object is to provide a refrigeration method utilizing a hydrocarbon refrigerant, wherein the amount of higher boiling impurities in the liquid refrigerant is markedly lessened.

Another object is to provide, in a refrigeration system utilizing a light hydrocarbon as a refrigerant, a means of cooling warm compressed vapors preparatory to the liquefaction thereof for return to the heat exchange step.

Other objects will be apparent in the light of the accompanying discussion and disclosure.

In accordance with this invention, a refrigeration process utilizing a light refrigerant may be operated continuously without the accumulation of higher molecular weight impurities in the liquid refrigerant. Such impurities comprise compressor lubricating oil imparted to the vapors during the compression step and hydrocarbons inherently present in the refrigerant as, for example, when employing propane as the refrigerant, in which case, from 0.1 to 2.0 per cent butanes may be present as impurities. Similarly, pentanes may comprise the chief impurities in an isobutane or normal butane refrigerant.

In conducting my process, the light refrigerant, inherently containing the impurities aforesaid, is vaporized in heat exchange with a substance to be cooled. The vapors thus formed are removed from the heat exchange step and mechanically compressed. As a result of contact between the vapors and certain lubricated parts of the compressor, lubricating oil is often imparted to the vapors in an amount in the range of 0.001 to 2.0 weight per cent. The higher molecular weight impurities thus present in the compressed vapors are removed therefrom in a scrubbing step utilizing a portion of the liquid refrigerant from the refrigeration system, usually the heat exchange step, as a scrubbing liquid. In the scrubbing step, warm compressed vapors are washed in counter current flow with downwardly flowing scrubbing liquid, in a suitable tower, preferably of the bubble cap type, although packed towers are quite satisfactory. The scrubbing liquid is partially vaporized during descent, thereby cooling the compressed vapors which leave the scrubbing tower at a temperature usually from about 5 to 10° F. above that at which the vapors would condense. The unvaporized portion of the scrubbing liquid is recovered at the bottom of the scrubbing tower and contains, in solution, the impurities removed from the ascending vapors. The scrubbing liquid thus contaminated is discarded from the system, if desired, or more preferably is separated into a portion substantially free of the impurities and a portion proportionately rich in the impurities, the former being returned to the refrigeration system and the latter discarded. Effluent vapors from the scrubbing tower are cooled, liquified and returned to the heat exchange step.

The amount of scrubbing liquid utilized is regulated under conditions so as to control the extent of cooling of the compressed vapors, whereby subsequent liquefaction is accomplished with ease and a highly efficient scrubbing action of the unvaporized scrubbing liquid is maintained.

To understand my process more fully and to further point out various advantages of my invention, reference may be had to the diagrammatic sketch which illustrates one type of appa-

ratus in which the objects of my invention may be accomplished. It is understood however, while this is representative in general of my process, minor variations and departures may be desirable in adapting the process to the various conditions within the scope of my invention.

Referring now to the drawing, a boiling liquid refrigerant 10, such as liquid propane, present in heat exchanger or evaporator, 11, is vaporized in heat exchange relation to a substance to be cooled which is present in coil 12. Refrigerant vapors from heat exchanger 11 are passed through line 13 to the intake of compressor 14 and discharged therefrom through line 15 into scrubber 17 at a point near the bottom. Cold liquid refrigerant is passed from heat exchanger 11 through line 18 and by means of pump 19 is introduced through line 20 and motor valve 21 to scrubber 17 at a point near the top. Scrubber 17 may be a packed column but is preferably a bubble type tower. However, baffles of other types are suitable.

The ascending vapors in scrubber 17 are thoroughly washed by the descending liquid, referred to herein as the scrubbing liquid. The major portion of the descending liquid is vaporized during its downward flow through the scrubber, providing thereby a source of cooling whereby the warm compressed vapors entering scrubber 17 are cooled to a temperature only slightly above the temperature at which they would initially condense, more commonly referred to as the dew point. The preferred temperature difference is in the range of from 5 to 10° F. By such partial vaporization and consequent cooling, the vapors are most efficiently scrubbed and the cool scrubbed vapors may be efficiently liquified by supplemental cooling. Unvaporized scrubbing liquid is recovered at the bottom of scrubber 17 at a point below the vapor inlet, and contains the impurities removed from the compressed vapors. These impurities include hydrocarbons having a higher molecular weight than that of the refrigerant, such as butanes and smaller quantities of pentanes, and compressor lubricating oil. Such lubricating oils may be hydrocarbon oils or may be nonhydrocarbon oils such as castor oil or a soap lubricant. Scrubbing liquid thus contaminated is passed from the bottom of scrubber 17 through line 22 to separation zone 23 where the contaminated scrubber liquid is separated into a fraction substantially free of contaminants and a fraction rich in contaminants. Steam coil 24 may be used to supply heat in zone 23 if desired. The contaminant-rich fraction is discarded from the refrigeration system through line 25 and valve 27. Contaminant-free refrigerant is passed, as a vapor, from the top of separation zone 23 and returned through lines 28 and 13 to the intake of compressor 14. Contaminated scrubbing liquid recovered from scrubber 17 may be discarded through line 26 and valve 36 if desired, and is done preferably, when the amount of unvaporized scrubbing liquid is so small that the separation aforesaid in zone 23 is not justified.

Cooled, scrubbed compressed vapors leave scrubber 17 through line 29 and are liquified in cooler 30. The rate of heat transfer in cooler 30 is much greater when receiving the refrigerant vapors at their dew point temperature rather than as a superheated vapor, thus greatly reducing the cooling surface required. Liquified refrigerant is then passed from cooler 30 through line 31 to storage 32 from which it is returned to

heat exchanger 11 through line 33 and motor valve 34.

The extent of cooling is of course, dependent upon the temperatures of the incoming vapors, and the quantity of scrubbing liquid introduced to scrubber 17. I find it most convenient to control any variance in the temperature of cooled, scrubbed, vapors leaving scrubber 17 by varying the amount of scrubbing liquid added. I do this by means of motor valve 21 which is actuated by temperature controller 16 and permits, thereby, a proper flow of scrubber liquid just sufficient to maintain the temperature of the cooled scrubber vapors at a desired set level. Controller 16 may be an instrument of any of the various known designs commercially available.

Liquid level 10 in heat exchanger 11 is preferably maintained at a constant value. This is especially advantageous in view of withdrawal of liquid therefrom through line 18. Liquid level 10 is preferably maintained by passing liquid refrigerant through line 33 and motor valve 34 which is actuated by liquid level controller 35. Controller 35 may be an instrument of any of the various known designs commercially available. Supplementary refrigerant may be added to the system, when desired, through valve 38 and line 31.

For convenience and clarity certain apparatus, such as pumps, surge tanks, accumulators, valves, etc. have not been shown in the drawing. Obviously such modifications of the present invention may be practiced without departing from the scope of the invention.

As will be evident to those skilled in the art, various modifications can be made or followed, in the light of the foregoing disclosure and discussion, without departing from the spirit or scope of the disclosure or from the scope of the claims.

I claim:

1. An improved refrigeration process utilizing a light hydrocarbon refrigerant, comprising maintaining a boiling mass of liquid refrigerant in heat exchange relation with a substance to be cooled, compressing vapors thus formed, vapors thus compressed containing heat of compression and higher molecular weight impurities, withdrawing a portion of liquid refrigerant from the zone of said heat exchange relation and contacting same with said compressed vapors in counter current flow, vaporizing a portion of the liquid during said contacting thereby cooling said compressed vapors and scrubbing same to remove said impurities, controlling the amount of liquid added during said contacting so as to maintain the temperature of the cooled, scrubbed vapors at the dew point of same, condensing said cooled scrubbed vapors and returning the condensate thereof to said boiling mass, recovering an unvaporized contaminated liquid from said contacting, separating said contaminated liquid into a contaminant-free vapor fraction and a liquid fraction rich in said contaminant, admixing said vapor fraction with vapors evolved from said boiling mass, and discarding the contaminant rich fraction.

2. In a refrigeration process utilizing a light hydrocarbon refrigerant, wherein liquid refrigerant is vaporized in heat exchange relation with a substance to be cooled, and the vapors therefrom are compressed, cooled and condensed, and the condensate thereof returned to the heat exchange step, vapors thus compressed containing higher molecular weight materials as impurities,

the improvement comprising withdrawing liquid refrigerant from the heat exchange step and contacting same with said compressed vapors in counter current flow thereto, recovering liquid contaminated with said impurities as a result of said contacting, and discarding the contaminated liquid.

3. In a refrigeration process utilizing a light hydrocarbon refrigerant, wherein liquid refrigerant is vaporized in heat exchange relation with a substance to be cooled, and the vapors therefrom are compressed, cooled, and condensed and the condensate thereof returned to the heat exchange step, vapors thus compressed containing higher molecular weight materials as impurities, the improvement comprising withdrawing liquid refrigerant from the heat exchange step and contacting same with said compressed vapors in counter current flow thereto, recovering liquid contaminated with said impurities as a result of said contacting, separating the contaminated liquid thus recovered into a substantially contaminant-free fraction and a contaminant rich fraction, passing said contaminant-free fraction to the refrigeration system, and discarding said contaminant rich fraction.

4. An improved refrigeration process utilizing propane refrigerant, comprising vaporizing liquid propane in heat exchange relation with a substance to be cooled, compressing propane vapors therefrom, compressed propane vapors containing butane inherently present therein and compressor lubricating oil imparted thereto by contact of the vapors with lubricated parts of the compressor, withdrawing liquid propane from the heat exchange step and contacting same with said compressed vapors in counter current flow thereto, vaporizing a portion of said liquid during said contacting thereby cooling said vapors and scrubbing same to remove butane and said compressor oil contained therein as aforesaid, controlling the amount of liquid propane added during said contacting so as to maintain the temperature of the cooled, scrubbed, propane vapors at a predetermined value at about the dew point of same, condensing the vapors and returning liquid propane thus formed to the heat exchange step aforesaid, recovering from said contacting a propane rich liquid containing butane and compressor lubricating oil as contaminants, separating said propane rich liquid into a substantially pure propane fraction and a fraction rich in said contaminants, returning said pure fraction to the refrigeration system, and discarding said contaminant rich fraction.

5. An improved refrigeration process utilizing a light refrigerant, comprising vaporizing liquid refrigerant in heat exchange relation with a substance to be cooled, compressing vapors thus formed, vapors thus compressed containing heat of compression and higher molecular weight impurities, withdrawing liquid refrigerant from said heat exchange and contacting same with said compressed vapors in counter current flow, vaporizing a portion of the liquid during said contacting thereby cooling said compressed vapors, controlling the amount of liquid added during said contacting so as to maintain the temperature of the cooled scrubbed vapors above the dew point within a range not greater than 10° F. thereabove, condensing said cooled scrubbed vapors and returning the condensate thereof to said heat exchange, recovering an unvaporized contaminated liquid from said con-

tacting, separating said contaminated liquid into a contaminant-free fraction and a fraction rich in said contaminant, returning said contaminant-free fraction to the refrigeration system, and discarding the contaminant rich fraction.
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